



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

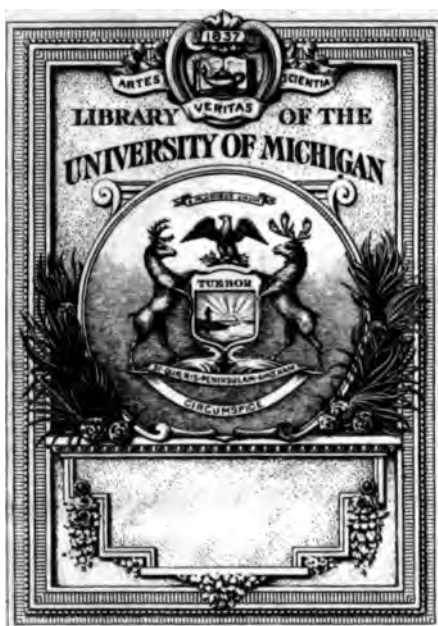
- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

B

939,225



GE
522
.065
E5
1801

THE
NATURAL HISTORY
OF
VOLCANOES;

INCLUDING
SUBMARINE VOLCANOES,
AND
OTHER ANALOGOUS PHENOMENA.

BY THE ABBÉ ORDINAIRE,
FORMERLY CANON OF ST. AMABLE AT RIOM IN
AUVERGNE.

TRANSLATED
FROM THE ORIGINAL FRENCH MANUSCRIPT,

By R. C. DALLAS, Esq.

LONDON:
Printed by H. Baldwin and Son, New Bridge-street,
FOR T. CADELL, JUN. AND W. DAVIES, STRAND.

M DCCC I.

TO THE RIGHT HONOURABLE

SIR WILLIAM HAMILTON, K.B.

V.P. TRUST. BR. MUS. F.R.S. F.A.S. F.R.S.

ED. M.R.I. A. AC. R. SCIENT. ET HUM. LIT.

NEAPOLIT. INSTIT. BONON. ET SOC. NAT.

SCRUTAT. BEROLIN. SOC. AND LATE HIS

BRITANNIC MAJESTY'S ENVOY EXTRAOR-

DINARY AND MINISTER PLENIPOTENTIARY

AT THE COURT OF NAPLES.

SIR,

IT has been reserved for you, to direct the public attention to the portion of Natural History which is the subject of this Treatise. Not satisfied with having led the way to it, you have gone through almost every part of it. Amid the duties of an embassy, which, for the space of thirty-seven years, you have so discharged as to justify the confidence of the great and good Monarch whose representative you were, and

at the same time to enjoy that of His Sicilian Majesty, you have devoted your hours of leisure to the task of increasing the knowledge of the various Academies of Europe, by philosophical observations, and profound inquiries, which are, and always will be, the basis of this science.

Impressed, in common with the rest of the world, with a just sense of the acknowledgments due to you, I was naturally led, on hearing of your return to England, to offer you a testimony of my respect, by dedicating to you the result of my own labours on the interesting subject of subterranean fires. Your acceptance of it is a mark of your goodness, the greatness of which I feel the more, from the reflexion of your having previously known, that on one or two points I had used a freedom which the candour of your mind allows on subjects of this nature: a candour as rare as the great superiority of character which it demonstrates.

I am, SIR, your most obliged,

And most obedient humble Servant,

ORDINAIRE.

P R E E A C E.

THE phenomenon, the elucidation of which I have dared to undertake, has, within the last half century, become more peculiarly an object of public curiosity. This, I believe, is the effect of the many learned writings which have been the consequence of the frequency of the eruptions of Vesuvius, and of the violence with which they have constantly appeared in the course of that time. It is strange, however, that this curiosity should have been awakened so late, for, besides that there is not a grander or more astonishing sight in the world than a volcano during an eruption, there is, perhaps, no branch of natural history of which the study is more attractive.

The mind delights to investigate the original causes by which such mighty fires were kindled in the cold and tranquil bosoms of the loftiest mountains; the inexhaustible means by which they keep themselves alive for so long a series of

ages; the incitements of their paroxysms; the source of those never-failing emissions of lava, and the power which can raise that lava bodily from the bottom of the abyss where it was melted. We are interested in the history of their revolutions; we wish to know how volcanoes become extinguished; how sometimes they only slumber; and in what case their revival may be apprehended.

These questions, which involve many others, are by no means peculiar to volcanoes on land; most of them equally relate to *submarine volcanoes*: indeed, the investigation of the latter is attended with discussions still more stimulating to curiosity. The existence of a mountain retaining its fires, although absolutely buried in the sea, and opening and shutting from time to time in that critical situation, is a phenomenon so marvelous, that to believe it we must have it authenticated by a regular history of its eruptions. When the fact is established, we are led to require a reason for the singular contrast of position between this volcano, which is sunk below the level of the ocean, and a volcano on

land, which always occupies lofty summits, and generally the loftiest on the earth? We wish to know how a burning gulf can remain open in the bosom of the ocean for months, without being inundated; and to learn the manner in which, amidst frightful conflicts, this opened abyss at length closes.

I have endeavoured in the following Treatise to illustrate all these points, and the questions that arise from them. My endeavours will, perhaps, throw some additional light on this grand phenomenon, but I have not the presumption to think that my explanation of this wonderful work of Nature will prove fully satisfactory in the whole of its operation : in the inquiry we are too often reduced to conjectures and probabilities. Our Creator appears to have reserved to himself the knowledge of the two extremes of his economy of Nature, the origin and the end of every thing. I say our Creator; for Nature, distinguished from its Author, is merely a creature of the imagination, a word destitute of meaning. In natural philosophy, as in metaphysics, as soon as we have attained a certain point, it is in vain

we endeavour to dive deeper, the understanding has no longer a sure hold in stretching to seize the truth which it is conscious is beyond it. We then deal largely in hypotheses, each framing his own, and the judgment of those who possess the highest reputation becomes a part of what we call Science: and yet, what are our hypotheses but a formal acknowledgment of the real limits of our understanding?

The variety of points necessarily arising from the discussion of this subject in its whole extent, induced me to divide the work into sections. Besides the greater precision of this mode, the Reader, by means of the numbers, will find it easier to refer, on occasion, to points connected with the topic directly before his eyes. To simplify the arrangement as much as I possibly could, I have also thrown the sections into separate chapters, according to the affinity of the subjects.

CONTENTS.

CHAP. I.

	Page
<i>MOUNTAINS in general contain large chasms. They differ from one another in their internal structure. The same mountain consists of various substances. In some, pyrites are found in large quantities. The burning of a mountain may be caused by those minerals. Emery's experiment. Why does a mountain in taking fire always open at its summit? Other probable causes of the burning of a mountain.</i>	1

CHAP. II.

	Page
<i>Of the Crater. When widest. In what manner its contraction is effected. The intrepidity of certain observers.</i>	8

CHAP. III.

<i>At its commencement a volcano has but one mouth. Many vents show the exhausted state of a volcanic mountain. A description of the Devil's Mouth, and of some other volcanoes in similar situations. The state of that in the island of Amsterdam; the prodigious heat of its waters. The difference between Fahrenheit's thermometer and that of Réaumur.</i>	13
--	----

CHAP. IV.

<i>There are no volcanoes in plains. Of fires in mines. Of the fires called firedamps</i>	
---	--

CONTENTS.

xi

	Page
(moffettes.) <i>Of permanent fires on the surface of the earth. The state of mount Kargousch-Kougisch.</i>	20

CHAP. V.

<i>Of internal permanent fires, commonly called central fires. Proofs of their existence. These fires the most common cause of earthquakes. The formation of a volcano would be useful in some places. Central . . . fires may cause the burning of a mountain. To them is owing the phenomenon of the Phlegræi Campi.</i>	31
---	----

CHAP. VI.

<i>Are all mountains produced by subterranean fires? Are not the burning mountains at least produced by them? Proofs of the conflagration being posterior to the formation of the mountain.</i>	44
--	----

CHAP. VII.

Page

<i>Are all volcanoes formed under the sea?</i>	
<i>The reasons that have given rise to this hypothesis discussed. The characteristics that distinguish volcanoes from the general subterranean fires.</i>	51

CHAP. VIII.

<i>All volcanoes above the sea occupy lofty heights. Their elevation is still more evident in islands. Of the fires formed at the foot of a volcano. The cause of the elevation of volcanoes on land.</i>	59
--	----

CHAP. IX.

<i>The volcanoes of the Moon have eruptions equal to those of the volcanoes of our globe. That planet abounds with very high mountains.</i>	72
--	----

CHAP. X.

	Page
<i>The striking contrast between the great elevation of the volcanoes on land, and the lowness of the submarine volcanoes.</i>	80

CHAP. XI.

<i>Islands rendered uninhabitable by their volcanoes. The singular state of Iceland, in respect to its fires, and the heat of its waters. The means of discovering the cause of the heat of hot springs. These waters begin to boil in less time than common cold water.</i>	82
---	----

CHAP. XII.

<i>Volcanoes are not vents for a grand reservoir of fire in the centre of the globe. The astonishing quantity of the fires of Kamtchatka.</i>	96
--	----

CHAP. XIII.

	Page
<i>Volcanoes render the places around them fertile and healthy. The danger of their vicinity.</i>	103

CHAP. XIV.

<i>What are the causes of the convulsions of a volcano? How do these causes act? Their effects upon the mountain, upon the adjacent places, and often at a very great distance.</i>	108
--	-----

CHAP. XV.

<i>The sea, when near, partakes the motions of the earth. Prodigious oscillation of the sea at Awatcha. Illusion experienced by the people of Naples in 1779. The eruption of a volcano puts an end to the great conflict of nature.</i>	117
---	-----

CHAP. XVI.

Page

The eruption of a volcano one of the grandest sights a man can behold. An idea of it. What causes it? The overspreading of the burning matter at the top of the column. Its whole form. The fall of the ejected substances. The prodigious distance to which they are sometimes carried. 124

CHAP. XVII.

Of the dry fog in 1783. It did not proceed either from the convulsions in Calabria, or from those in Iceland. The opinion of the Abbé Bertholon of the cause of that phenomenon. 130

CHAP. XVIII.

	Page
<i>Of the nature of the substances ejected at the time of an eruption. Of the lava. Of the cause of its overflow. The manner in which it is disgorged.</i>	138

CHAP. XIX.

<i>The incredible quantity of lava that issues from a volcano. The immense void it must leave. The principal fiery pits of volcanoes must have horizontal branches.</i>	143
--	-----

CHAP. XX.

<i>The crater of a volcano sometimes vomits boiling water. Whence does the water proceed? Of the water-volcano of St. Jago de Guatimala.</i>	149
---	-----

CHAP. XXI.

	Page
<i>Nature proceeds uniformly in the discharge from volcanoes. Wherever the lava flows, it creates a sterility of an indefinite duration. Quarries opened in the lava. The variety of colours in the lava. Vitrified masses most common near certain volcanoes.</i>	156

CHAP. XXII.

<i>Volcanoes become extinct, from the mines being exhausted; from the falling of the summit; from the rending of the sides of the mountain; from the sinking of the mountain itself into its own abyss; from the entire inundation of the reservoir of fire, and from its being dried up.</i>	164
--	-----

CHAP. XXIII.

	Page
<i>The earth has been desolated by a great number of volcanoes. The probable cause of the extinction of those in the islands of the Grecian Archipelago.</i>	181

CHAP. XXIV.

<i>The Giants' Causeway. Its wonderful formation. Various opinions respecting its origin.</i>	189
--	-----

CHAP. XXV.

<i>The volcanoes known to be burning on the globe. The volcanoes on the Continent and in the islands of Europe.</i>	200
--	-----

CONTENTS.

xix

CHAP. XXVI.

	Page
<i>Volcanoes on the Continent and in the islands of Asia.</i>	204

CHAP. XXVII.

<i>Volcanoes on the Continent and in the islands of Africa.</i>	213
--	-----

CHAP. XXVIII.

<i>The volcanoes of America: first, those of the northern part; 2dly, those of the southern part; 3dly, those in the islands corresponding to the Continent of the New World.</i>	215
--	-----

CHAP. XXIX.

	Page
<i>Observations on the general proximity of volcanoes to the sea. What is the cause of it?</i>	227

CHAP. XXX.

<i>An extinguished volcano may be rekindled. Vesuvius, after lying apparently extinguished for several centuries, took fire again in the reign of the Emperor Titus. The death of Pliny the naturalist. Vesuvius, after burning about a thousand years, was again apparently suppressed.</i>	232
--	-----

CHAP. XXXI.

<i>The great antiquity of Vesuvius and Etna as volcanoes. Did the Deluge necessarily</i>	
--	--

CONTENTS.

xxi

	Page
<i>extinguish, as has been said, all the volcanoes then burning? Other volcanoes which it may be presumed have been rekindled. Grounds for thinking that Etna has been formerly extinguished.</i>	239

CHAP. XXXII.

<i>Of the Mud-Volcano at Maccalouba. Its extraordinary eruptions. The manner in which this phenomenon may be explained.</i>	249
--	-----

CHAP. XXXIII.

<i>Discovery of a phenomenon of a similar kind made by M. Pallas. Its eruption in 1794. How explained by that author.</i>	255
--	-----

CHAP. XXXIV.

<i>The Hydropyric Volcanoes of England. Reflexions on those Phenomena.</i>	266
---	-----

CHAP. XXXV.

<i>In what cases, and where, is it to be feared</i>	Page
<i>that volcanoes may again break out ?</i>	273

CHAP. XXXVI.

<i>Of submarine Volcanoes. Their distinguish- ing character. The number of those known. Volcano of Santorin. Periods of its first eight eruptions in the course of more than two thousand years, and what they produced. Particulars of the ninth eruption in 1767. Production of Black Island.</i>	276
---	-----

CHAP. XXXVII.

<i>The Maritime Volcanoes of the Azores : 1st. The eruptions of the volcano of St. Mi- chael : 2d. The eruption of that of St. George.</i>	289
--	-----

CHAP. XXXVIII.

	Page
<i>Submarine Volcanic Mountains not the productions of central fires. Buffon's opinion respecting their origin. His hypothesis defended. The manner in which the submarine Volcano forms itself. Objection to this opinion: its solution.</i>	295

CHAP. XXXIX.

<i>Why does not the sea inundate a submarine Volcano when it opens? How does the crater of a submarine Volcano close itself under water?</i>	313
--	-----

CHAP. XL.

<i>Where was the ancient Atlantic territory situated? Of what extent was it? Its</i>	
--	--

CONTENTS

Page

*destruction, and the consequences that must
have followed. The reasons for which it
has been presumed that its ruin was caused
by its volcanic fire. 219*

THE NATURAL HISTORY
OF
VOLCANOES.

CHAP. I.

Mountains in general contain large chasms. They differ from one another in their internal structure. The same mountain consists of various substances. In some, pyrites are found in large quantities. The burning of a mountain may be caused by those minerals. Emery's experiment. Why does a mountain in taking fire always open at its summit? Other probable causes of the burning of a mountain.

§ 1. **A**LL mountains are not solid and compact bodies : in most there are chasms of greater or smaller extent. There are some, within which one may walk forward on a level for several hours, and others which extend to a great depth below their visible bases. It would be endless to enter into a detail of this kind.

The knowledge we have, that springs and rivers flow from mountains, is enough to convince us, that there are many that contain immense cavities. But the highest are usually formed with one or more perpendicular fissures which terminate, at a great depth, in enormous caverns.

§ 2. Mountains differ from one another not only externally, but by their internal structure and qualities. A quarry, or a mine, shall be found in one and not in another though close to it.

§ 3. Nor is the whole body of a mountain of the same nature; it is not a homogeneous mass, but a compound of various substances. Although the prevailing matter of it be a particular metal, mineral, salt, or stone, all other metals, minerals, salts, and stones, will be found scattered through it in certain quantities.

§ 4. Among the mixt bodies we meet with in mountains, there is one sort in which sulphur and iron are so combined that if put into water, their insensible parts enter into sudden and violent action, which communicating itself to the water, gives it a warmth and ebullition almost

as great as that which our common fires produce. These substances are ranked in the number of minerals. They are called *pyrites* or fire-stones, which when wetted create heat. The quality of coal depends upon its assimilation to pyrites. The Scotch coal, in which sulphur and bitumen predominate, makes a clearer but less lasting fire than that of Newcastle, in which there is a greater proportion of iron. Hot springs and hot baths are chiefly produced by pyrites. Their warmth and properties result from the quantity and quality of that mineral. We may judge of the power of pyrites, and of the prodigious collection of it in some mountains, by the proof we have that the mineral hot waters, which have been recommended for nearly two thousand years, have to this day retained all their original properties. The waters of Bath in this country were frequented by the Romans as they are by the present generation. The remains of their baths, in good preservation, were discovered at the depth of twenty feet, in the year 1755, by workmen repairing the bath called the Duke of Kingston's. I was witness to a similar discovery

which was made at Luxcuil, in the year 1766, but the depth was not more than eight or nine feet. There was an inscription bearing the name of T. LABIENUS, in very large Roman letters. Most of the waters mentioned by Pliny the naturalist are still known, and retain all the power they possessed in his days.

§ 5. If the cavity that contains the pyrites, or the immense bed where it lies, be entirely overflowed, and the water do not dry up, there will never be any thing remarkable in a mountain under such circumstances, except its hot waters. But if only a quantity of moisture sufficient to set the pyrites into a state of effervescence be admitted, it will take fire. Mr. L'Emery's experiment to produce fire and make an artificial volcano is well known and may be tried by any person. With twenty-five pounds of iron-filings he mixed an equal quantity of flour of sulphur, and worked it up with water into a paste rather hard than soft, which he put into an iron-pot : he then covered it with a piece of cloth and buried it a foot deep in the ground. In nine or ten hours after, the earth appeared in motion,

became hot, and flames soon followed. The experiment may be made with equal success by reducing the quantity even to a pound of each of the ingredients.

§ 6. Now let us suppose that the same mountain contains sulphur, rock-salt, nitre, bitumen, and some mines: they would soon be set into action by fire, and all the parts of the inside of the mountain would be attacked by the flames. Gunpowder, the terrible effects of which are but too well known, is a simple composition of nitre, coal, and sulphur. To three pounds of nitre are added eight or nine ounces of coal, and three ounces of sulphur. According to Boyle, in firing a cannon, the rapidity and intensity of the fire depend upon the sulphur and coal; and upon the nitre depend the expansion of the air and the force that throws out the ball and causes the report. For the same reason, air and vapours extremely rarified would agitate the mountain: it would shake from its base, and it would open at its summit—1st. because the summit being the extremity and the

part farthest from the centre of the motion, is the point where the shock would be strongest : 2dly, the peak or summit of a mountain is the part the least protected, and the weakest : 3dly, because the air, in its struggles to obtain a vent, striking at once against all the sides, must necessarily make the opening at the middle point above.

§ 7. Besides this manner of explaining the catching fire in the heart of a mountain, it is allowed that there may be other causes. We find sometimes that vapours pent in deep mines, occasion very troublesome conflagrations. The ill consequences that have attended these have given rise to various modes of prevention now in general use. Earthquakes are no doubt frequently the effect of such conflagrations produced in very low subterraneous caverns. It is possible, then, that flames so kindled in caverns situated at the base of a mountain charged with all the necessary materials, should set it on fire and render it volcanic. We shall see, as we go on, that in many places the earth conceals

immense fires within its bowels. These, in spreading, may find or be able to open communications with mountains of the nature described, and set them in flames.

CHAP. II.

Of the Crater. When widest. In what manner its contraction is effected. The intrepidity of certain observers.

§ 8. **T**HE opening at the summit of a mountain through which a volcano, when raging, vomits its fires, and from which smoke continually issues, is called the crater, or mouth. This in some volcanoes is more than a league in circumference, and in others not so much. The crater of Vesuvius is upwards of two English miles, that of Etna considerably more. The crater of the same volcano is not always of the same dimension. It is larger after a violent eruption, because the eruption throws off from the top, or precipitates to the bottom, the substances with which the continuance of a thick smoke, in the course of the years of rest, gradually contracts very considerably, and some-

times entirely choaks up, the head of the volcanic shaft.

§ 9. This contraction has some remarkable peculiarities. From the burning bottom of the abyss there are constantly rising very greasy fuliginous substances which, slowly at first, contract the upper circle of the gulf. As the mouth diminishes the less are the greasy vapours, ashes, and pumice-stones which rise, dispersed; so that in time the work encreases prodigiously by them, always contracting the head of the shaft. The action of the fire being thus more and more concentrated, this excrescence necessarily assumes the form of a real cone whose base adheres to and rests on the crater, but on the inside, so that to come at it one must descend some way from the brink of the crater: in a descent made some years ago into that of Vesuvius, the depth was from 80 to 90 feet. A very accurate idea of this state of that volcano was given by a painting of it, exhibited at No. 160, in Oxford-street. However, when the mountain remains long at rest, this void fills, the base of the cone becomes more solid,

and it encreases its own height, which adds to that of the mountain. There have been cones formed on Etna, which have risen a mile above its immense crater. Sometimes they are so overloaded as to fall by their own weight, at others they are thrown down by a violent quaking of the mountain; and in some cases a sudden eruption of the volcano has shivered them to pieces, part falling into the abyss, part on the sides, and even beyond the base of the mountain: and indeed nothing is more variable than the external aspect of a volcano: a violent eruption is enough to produce such a change as renders it hardly to be known again. Ten thousand men, says Sir William Hamilton, working for a century could not effect such an alteration on the surface of Vesuvius, as was produced by the hand of Nature in a few hours, by the eruption of 1794.

§ 10. There have been men, and there are many now, bold enough to venture to the very extremities, to expose themselves upon the brittle lips of these formidable mouths for fire, in order to sound the mysterious depths with

the eye. The Emperor Adrian visited the crater of Etna twice, although a tedious and very laborious undertaking. The first time he saw it, it was in a state of rest ; but some years after he happened to be in Sicily when an eruption took place. On a similar occasion Caligula, as we are told by Suetonius, fled in a cowardly manner from the island. Adrian, on the contrary, eagerly embraced such an opportunity, and again ascended Etna, the better to enjoy the grand phenomenon it offered to view. There are persons who have even endeavoured to scale the burning and cracked cones of which we have been speaking : and several have lost their lives in attempting to gratify this dangerous curiosity. Some, bolder still, have been known to have themselves lowered into the abyss suspended to long ropes fixed to the cinder brinks of the crater. This was done in 1750 by Soufflot, the celebrated architect. About thirty years ago, or a little more, an English Bishop caused himself to be lowered to a rock which projected in Vesuvius, whence he contemplated as much as he could of the vast inside of that

volcano. Its bottom, which he judged to be very low, appeared to him to be a lake of fire, at the top of which ran bluish flames. By the gloomy light they gave, which was rendered still more feeble by the smoke that rose from them, he observed that the sides within were in many places stuccoed with a sulphur partly yellow and partly of a reddish colour. He also perceived a quantity of sal-armoniac. Being by his position confined to a perpendicular view, he could of course, form no judgment as to the extent of this lake of fire, which he reasonably presumed had retreats, and extended itself widely in the hollow base of the mountain.

CHAP. III.

At its commencement a volcano has but one mouth.

Many vents show the exhausted state of a volcanic mountain. A description of the Devil's Mouth, and of some other volcanoes in similar situations. The state of that in the island of Amsterdam: the prodigious heat of its waters. The difference between Fahrenheit's thermometer and that of Réaumur.

§ 11. **T**HERE are volcanoes which besides their crater have other vents, through which when burning they discharge their lava: but that was not their original state. When the mountains were fresh they had but one mouth, and that was the crater. This is still the case with all those volcanoes that possess sufficient solidity to resist the action of their fires. We have the dates of several of the new openings that have been formed in the sides of some others. I must, nevertheless, observe that in

the multitude of volcanoes known to us, there is one that has from its origin had a double mouth : I mean the one near Colima, in the province of Mechoacan, in Mexico. It is described by Dampier : the mountain which is very lofty, and of an immense size, terminates in two distinct peaks ; both are open, and at the same time vomit fire and lava : they may be considered as two chimneys raised over the same fire-place. At the foot of this mountain is found the oleacazan, a valuable plant, esteemed for its quality in reviving persons and recruiting their exhausted strength, and also regarded as a sovereign remedy for all poisons, whether internal or external.

§ 12. The multiplicity of vents is a certain sign of an exhausted state of the mountain. Mount Vesuvius is at present in this condition. Its eruptions for the last sixty years having been both more frequent and more violent than in former ages, the fire by working on its sides has weakened them prodigiously. It still ejects substances through its crater, but the lava is now scarcely ever disgorged at the summit.

The sides from being worn away easily yield a passage, when a fermentation takes place in the volcano. In this century (*the 18th*) Vesuvius has discharged its fires in seven or eight different places, and particularly during the last eruption of 1794. One may venture to predict that, if the eruptions return as frequently and as violently as hitherto, a third of the highest part of this mountain will, before the lapse of another century, be suddenly engulfed by some of its agitations.

§ 13. In the lake Nicaragua, in Mexico, there is a high burning mountain, which has lost part of its crater on the side that looks northward to the sea, into which the lake disembogues. It appears open a considerable way down, and wears such a singular aspect when burning, that it has no other name among the English sailors than that of the *Devil's Mouth*. From this state of it, it is not probable that it should continue much longer a volcano: it throws out flames, but seems scarcely equal to an eruption. The combustible matter, the vapours, and the air are no longer confined, but readily make their way. Mount Fesi, in Japan,

is also open, and has been so for 150 years, but though formerly very formidable, it is now remarked only for its smoke and a few sparks. The state of the volcano of Zibbel-teir, or the Mountain of the Bird, is very extraordinary, and perhaps unparalleled. This mountain was seen by Mr. Bruce, in an island of the same name in the Red Sea, in latitude $15^{\circ} 38^m$ two degrees East of Jedda, and of which he speaks in his Travels. *Vol. ii. p. 97.* It has four openings at the top through which smoke rises, and flames, it is said, sometimes issue. The island, which may be about twelve leagues in circumference, is full of pumice-stones and sulphur. If this state be owing to its antiquity, as is probable from its feebleness, it is likely that a very large region of the summit will soon fall in, and the volcano expire, as was the case with that of Foosht, a little more to the East, in the same sea, and mentioned by the same author prior to his notice of the Zibbel-teir.

§ 14. When the ship that carried out Lord Macartney to China touched, in the month of February 1793, at the island of Amsterdam,

which lies in the Indian ocean, about four hundred leagues South-east of the Mauritius, the volcano which constantly and violently agitates that island was seen vomiting fire through six mouths. We may presume that a mountain so worn and full of openings will shortly be destroyed by its fires.

I do not believe that there is another spring in the world so hot as that which was taken notice of in the island of Amsterdam. We are informed, in the account of Lord Macartney's embassy to the Court of Peking, by Eneas Anderson, that large pieces of meat were thoroughly boiled in it in less than six minutes. The water of the new Giezer, of which we shall take notice in section 40, is as hot as common boiling water, that is, 212 of Fahrenheit's thermometer, or 80 of Réaumur's, but this degree of heat is far from being equal to produce the effect mentioned by Anderson. Both these springs nevertheless owe their heat to the volcanoes near which they rise: but that of Giezer is probably not so near to the volcanic fire as that of Amsterdam.

§ 15. Fahrenheit's thermometer is more generally used by the English, and Réamur's by the French. A person unacquainted with the difference between them must be puzzled in reading an author who mentions but one of them ; I shall, therefore, here present the reader with a rule, by which having the degree of the one he may always find the corresponding degree of the other.—If it be a degree on Fahrenheit's, suppose, for example, that just mentioned of boiling water, or 212 ; subtract 32, multiply the remainder by 4, divide the product by 9, and the quotient of 80 is the degree of boiling water on Réamur's. If, on the contrary, the degree be given from Réamur, the preceding operation is to be reversed : multiply 80 by 9, divide the product by 4, and add 32 to the quotient, which will give 212, the degree of boiling water on Fahrenheit's. The same rule will serve for the degrees below the freezing point. Such was the intense cold experienced by Mr. Pallas, on the 7th of October 1772, at Krasnajar in Siberia, although that town is in the same latitude as Edinburgh, that mercury

which had been well purified froze and became malleable. Réamur's thermometer was at 50 below the freezing point, consequently Fahrenheit's at $144\frac{1}{2}$, the operation being $50 \times 9 = 450 \div 4 = 112\frac{1}{2} + 32 = 144\frac{1}{2}$.

CHAP. IV.

There are no volcanoes in plains. Of fires in mines. Of the fires called firedamps (moffettes.) Of permanent fires on the surface of the earth. The state of mount Kargousch-Kougisch.

§ 16. **I**T has always been remarked that there are no volcanoes in plains. The investigation of the different fires that act under ground justifies this observation, and shows the reason of it. A coal mine may take fire and continue burning. There are mines in Scotland, which, it is presumed, according to a passage in Chambers's Encyclopaedia, have been burning ever since the time of Agricola, that is for 1700 years past. I know one in Forez, near St. Etienne, which has been burning for two centuries. Near Saarbruck-à-outteveiller, there is a mine of peat, which has been on fire from time immemorial. As mines are dug where there are no chasms in the

earth, when by chance one takes fire, the fire insensibly proceeds, and by degrees consumes in silence the inside of the mine, of course it cannot be worked or even approached. But as the air has no circulation in it, and is scarcely active, from having only a solid body to act upon; and there being in it no kind of matter in fusion, it is evident that it can give birth neither to explosions nor to an efflux of lava: in short that it cannot produce a volcano.

§ 17. The formation of *fire-damps* (*moffettes*) in the galleries of certain mines where the air has not a free circulation, is a terrible phenomenon, but entirely different from a volcano. A mine that is worked emits a great quantity of exhalations in a confined space: if these are not dispersed, they mix, hang to one another, and become visible in the forms of cobwebs moving to and fro. Miners who are aware of their effects, no sooner perceive them than they put out their lights and lie down flat on their faces; for those combustible substances soon proceed to action, and suddenly produce detonation and

pulvis fulminans. It has sometimes happened from the abundance of such exhalations, that the air in the mine has caught fire, and rushed out carrying all the props along with it. All this is but transient and momentary.

The phenomenon of which Pliny speaks, (b. 2. ch. 85.) seems to have had no other cause than a fire of this kind, though of a much greater magnitude. A year before the social war, a period when Italy was extremely enlightened, when Cæsar, Pompey, and Cicero were born, two hills near Modena were seen violently convulsed, and striking several times against each other. In the shocks, volumes of flames rolled out between them. Pliny adds that this prodigy was seen by several Roman Knights and a multitude of people. It is highly probable that a fire suddenly kindled in the cavity of one of the hills, and rapidly communicating to a similar cavity under the other, was the cause of this phenomenon. As it left no marks nor ever happened again, it cannot be ranked among volcanoes.

§ 18. Leo, the African, towards the end of

his third book, speaks of an open cavern in a valley near mount Benigua-zeval, in the kingdom of Fez, in Barbary, from which smoke continually issues, and which often vomits large flames ; and if branches of trees are thrown into the entrance they are immediately consumed. This is all the account given by that author, although he was upon the spot, and it does not bear the characters of a volcano ; it is altogether too simple and too confined : neither can it, for the same reason, be the mouth of central or subterranean fires of which we are about to speak. It appears to be merely the natural fissure of a mine on fire, and in which there is a great quantity of bitumen.

In the South-east of Natolia Proper, there is a great mountain, the bottom of which, on the South aspect, is bathed by the Mediterranean : it is called Mount Climax, and is celebrated for a very dangerous march performed at its foot through the sea by Alexander the Great, at the head of his army. To the north of this mountain, near Satalia, there is a large burnt space whence flames incessantly issue, but not accom-

panied either with detonation or lava. This state of it is very ancient, for we find this place among others mentioned in the *Periplus of Scylax*, under the article *Lycia*, where the author tells us that it is continually burning. The stillness of this fire excludes it from the class of volcanoes. This phenomenon will perhaps be accounted for in the observations we shall hereafter make.

In the province of *Curdistan*, near the town of *Kerkech*, to the S. E. of *Arbela*, there is a surface of some extent over which a flame continually runs, and has for many ages; for *D'Anville*, in the 2d vol. of his *Ancient Geography*, in relating the fact as still existing, puts us in mind that it is mentioned by *Strabo*, who wrote in the reign of *Tiberius*. From the nature of this fire it cannot be thought a volcano, and its situation indicates the cause of it; the country furnishing a great deal of *naphtha*. It is known that all bituminous mines have the peculiar property of rising towards the surface of the earth. It is probable that the one we are treating of, spreading as it rose, covered this

space of ground, and caught fire accidentally. They who have seen this kind of mines will be less astonished at the permanency of this phenomenon. Bitumen gently oozes through the earth which it impregnates ; and the flame as it wanders and runs along can consume but a small quantity of it, which is furnished by the vast stock in the mine. This brings to mind the prodigy in the temple of the Gaurs, who adore a perpetual fire, a few leagues from Baku, in the peninsula of Abschiron, on the Caspian sea. Doctor Lerch, physician to the Russian army, has given a very interesting account of it.

In other places there are smaller permanent fires produced on the surface of the ground, but no where are they seen accompanied with the properties of volcanoes.

§ 19. In the long chain of the Oural, in the country of the Baschirs Mursalarskis, which is subject to Russia, about 140 leagues due North of the lake Arall, there is a mountain nearly 1200 yards of perpendicular height, which is mentioned by some authors as a volcano ; but this is

an error : nor ought it even be classed among the fires really permanent. This mountain has been on fire, and is perhaps still so, but only on its surface : the fire is not in its centre ; it is confined to the outside, at the first layers of the earth. The circumstances attending this phenomenon are sufficiently curious to render apology unnecessary for introducing a sketch of the description given of this burning mountain, by the celebrated Mr. Pallas, in the 2d vol. of his Travels, page 72, French edition.

The Baschirs call this mountain Kargousch-Kougisch. It runs from East to West, and its sides both North and South are steep. To the South two deep narrow passages form ridges, which give an appearance of three hills ; and there it was that the fire was seen, when Mr. Pallas visited the Kargousch-Kougisch on the 26th of May, 1770.

The mountain was originally entirely covered with wood ; it still was so at its summit on the North side, and on the quarters to the East and West : the southern aspect was the only one that had suffered. The author was told that

about ten or twelve years before, a very large and lofty pine, at the foot of the centre-hill, was struck by lightning; that the tree and even its roots had been burnt, and that the fire had thence spread by degrees. In 1770 it had consumed the whole forest of the centre hill except the tops. It had soon made its way to the South-east hill, but went out after making some ravages. The fire which three years before had communicated itself to the eastern hill was still burning, and had already spread very far.

There is nothing extraordinary in all this: it is only the duration of the thing that is surprising; for it should seem that in the course of ten or twelve years, the fire, assisted by the strength and variations of the wind, ought to have laid this woody mountain entirely bare. The immense forests that covered the whole island of Madeira were consumed in seven years.

But what is here worthy of being remarked, is, that the fire should attack and consume successively the very rind, if I may so express myself, of the mountain itself. The places which

have been burnt, says Mr. Pallas, are full of chinks and holes, whence there continually issues a light burning vapour, in which dry wood will take fire in less than a minute. In the night-time, or in stormy weather, the flames are seen rising to the height of ten or twelve feet. It is far from being safe to walk even where the ground is unbroken : one may sink to the knees in a soft burnt earth, and not be extricated without feeling the heat of the fire : yet there is no smell either of sulphur or of peat to be perceived.

The mountain is composed partly of a reddish kind of freestone, which the fire has rendered compact and sonorous, while it preserves a little of its calcareous nature, and partly of a soft stone which separates into lamina. It appears that between these strata there was matter of a different kind, which had been reduced to ashes. Here and there a mine of burnt iron is found.

Although Mr. Pallas does not inform us what kind of trees composed the wood of this mountain, we may presume that they were of the same

nature as those that grow on almost all the hills of the Oural, that is, pine, birch, larch, and oak. The tree struck with lightning we know was a pine. From what has been said respecting the state of the earth, there can be no doubt that the old and extremely multiplied roots of these trees had been able to force their way far among the different kinds of stone with which the ground is divided, and that vast numbers had also penetrated through the layers or beds just mentioned. These being burnt by the fire are reduced to the ashes there found. The fire is kept up by the mine of iron.

It is to be presumed, that since the year 1770, the fire has continued to spread over this mountain as before, that is to say, dying on one side, as happened on the South-east hill, and advancing on the other; and that it has either already ceased, or will in a short time cease, to burn from the want of fuel.

Of course it would be erroneous to place Kargousch-Kougisch in the number of volcanoes; nor should this mountain be made an exception to the formal observation of Mr.

Pallas, who, after going over the immense chain of the Oural, assures us in the 4th vol. of his Travels, page 602, that he had neither perceived any volcanoes burning, nor any trace of extinguished ones.

CHAP. V.

Of internal permanent fires, commonly called central fires. Proofs of their existence. These fires the most common cause of earthquakes. The formation of a volcano would be useful in some places. Central fires may cause the burning of a mountain. To them is owing the phenomenon of the Phlegræi Campi.

§ 20. **T**HERE are fires of an order very different from those abovementioned, and of which the effects are infinitely more terrible. They are called central fires, being concentrated at a great depth in the earth. Some authors have doubted their permanency. They allow that they are produced in deep caverns, but say that they are owing to electrical casualties, like those produced in the atmosphere, and are formed without any fixed seat and instantaneously. They reject the idea of permanent fires

and furnaces acting in the bowels of the earth.

The phænomena of nature are extremely diversified. There is no inconsistency in supposing that there are subterranean thunders. The fire-damps of our mines are in fact thunderbolts; and is it doubted that they are produced in the vast number of cavities in the earth? They were known to the Ancients: Pliny, the naturalist, expressly says, (l. 2. c. 79.) that earthquakes are an effect of thunders, formed in the bowels of the earth like those formed among the clouds. I think, nevertheless, that besides these temporary phænomena, our globe contains fiery abysses, and that those fires, whatever their origin may have been, are much more numerous in some parts than in others, but are in general very common.

§ 21. Without requiring credit for a simple assertion, as there are authors of great reputation who deny them, let me be permitted to adduce a series of facts, which referring all to a determined quarter of the surface of the earth, seem to me to demonstrate, in that quarter, the

permanence of subterranean fires. I shall follow the events of this nature, that took place in the course of a century and a half in Thrace, Asia Minor, and Syria; a vast extent which, from time immemorial to our days, has never ceased to give vent to this kind of fire. The following facts are extracted from M. le Beau's *Histoire du Bas Empire*, during the portion of time mentioned: This author has made a selection from the original authorities which he cites, and I have still farther reduced his selection: suffice it to say, that were I to attempt to enter into the details they would prove endless.

In 398, after frightful roaring noises and tremendous convulsions, the earth opened at several places in Thrace, and Bithynia, and vomited flames.

On the 20th of April 417, a violent earthquake was felt at Constantinople, and throughout the East. On that day the unfortunate town of Cybira, in Phrygia, so often razed before, entirely disappeared, being swallowed up amidst flames, with several villages dependent upon it.

On the 26th of January 447, horrid subterraneous noises were heard from the Black Sea to the Red Sea, and the earth began to be convulsed, and continued so, almost without intermission, for the space of six months. In many places the air seemed to be on fire : towns, large tracts of ground, and mountains, disappeared in both the Phrygias. Constantinople and Antioch were very much damaged.

Eleven years afterwards, similar disasters were repeated with similiar signs throughout those regions. The convulsion extended to the ground covered by the Archipelago : the Cyclades were particularly agitated.

In 518, Thrace experienced one of the most terrible earthquakes ever known. Scupa, the capital of Dardania, was swallowed up. At some distance the ground opened into a gulph of immense depth, twelve feet wide, and six leagues in length. Flames issued from it as out of a fiery furnace.

On the 20th of May 520, Antioch was overturned by a most dreadful earthquake. Two hundred and fifty thousand of its inhabitants

were crushed to death. A raging subterranean fire consumed the ground on which the town was built, and the circumjacent region to the extent of a diameter of forty-two miles, a surface of nearly fourteen hundred square miles. The unfortunate country was covered with fiery vapours. This was the state of things for six whole days, and it was renewed at times, though less forcibly, for six months.

Scarcely was the ground become firm, and Antioch beginning to rise, when in the month of November 528, it was, with several other great cities of the East, again thrown down by a terrible earthquake.

In 549, 551, and 554, all the provinces extending from Constantinople to Jerusalem suffered prodigiously by violent commotions of the earth; which in 556 seemed to have lost its stability at Constantinople, and throughout Naxos, from the 15th to the 25th of December. A hollow dreadful noise, like the rolling of thunder, was continually heard: black vapours issued from the ground, and loaded the atmosphere with clouds of smoke.

Soon after this, a very extraordinary circumstance happened at Antioch: the magnificent dome of the principal church had been thrown off its perpendicular by an earthquake, and remained inclining towards the North, supported by props. On the 31st of December 589, another earthquake, more violent than the former, threw down the props, and replaced the dome upright.

§ 22. Unquestionably, then, the bowels of the earth are deeply hollowed by many powerful fires, immense furnaces, where, beneath capacious vaults, several of which communicate with one another, gloomy flames are perpetually lurking. These fires agitate the superior parts of the globe, more or less, with earthquakes, according to the state of effervescence into which they chance to be thrown. Their remission, either when raging or still, depends upon too many circumstances, and causes too remote from human investigation, to permit our crediting what has been asserted of some ancient naturalists, that they foretold earthquakes long before they took place. The effects of those

fires are not so slow. It frequently happens that they are denoted even by the sagacious instinct of animals, which in such cases always exceeds our penetration, only a few minutes previous to their explosion. Sir Isaac Newton, in his *Treatise on Comets*, observing that it was also pretended by some authors that the Chaldeans and Egyptians foretold the return of those heavenly bodies, contends that neither of these assertions are true; and he supposes them, with great reason, to have risen from the ancient prejudices in favour of astrology. It was believed that they who were the most skilled in it, could discover what was passing in the depths of the earth as well as in the remotest regions of the Heavens; and the conjecture of the English philosopher is justified by a passage in Pliny, (b. 2. c. 79) in which we are told that the Ancients attributed earthquakes to the influence of the stars.

§ 23. When we consider the evils caused by subterranean fires, evils with which large countries are constantly threatened, we shall find no paradox in what has been asserted by some naturalists, that volcanoes are often advantage-

ous ; and that it is to be wished that they would break out in certain parts of the world.

A volcano doubtless has inconveniences, and very great ones, as we shall see ; but it removes still greater ones. From the knowledge we have of the state of the internal soil of Campania and Sicily, ever burning, and ever near combustible matter, it is evident that those countries would suffer both more essentially and more frequently than they do from Vesuvius and Etna, were it not for those vents.

The convulsions of the earth, labouring with internal fires, assume three very grievous characters ; for while the enflamed air which causes them remains confined they become prodigiously more violent, last longer, and spread wider : but if that air force a sufficient number of passages, stillness usually succeeds soon after. A large mouth, then, constantly open would weaken all those effects : it would, besides, be a greater security for the repose of the earth, and would prevent it from being so often agitated, by always rendering it easy for those internal exhalations to dissipate themselves. To reside

over immense caverns of fire is assuredly a very critical situation, but in such a situation it cannot be denied, that the formation of a volcano would be advantageous.

Natolia, Syria, Calabria, and Portugal are, and justly, under constant alarms. Were a volcano to break out in each of those countries, say between Smyrna and Kutaya in the first, between Aleppo and Antioch in the second, towards St. Euphemia in the third, and in Portugal, between Lisbon and Oporto, certainly those regions would become much safer.

§ 24. There can be no question but that the subterranean fires set in fusion an immense quantity of the same materials, which when disgorged by the mouth of lateral fissures of volcanoes, are known under the name of *lavas*. Being prodigiously swelled and raised in the bowels of the earth, they must naturally have sought to expand themselves and find passages. If in their action they made their way into the cavernous and deep bases of some mountain, being then strictly confined, they must have agitated it, opened it at the summit, as we have

described, have risen, and poured out through the crater they then formed.

It is probable that from these fires originated most of the volcanoes, which, according to the best informed modern travellers, existed in great numbers in Asia Minor, and Syria; such as Olympus, in Mysia; Ida, in Phrygia; Sipylus and Mimas, in Lydia; Amanus, to the North of Aleppo; and Casius, to the South-east of Antioch. At present there are no volcanoes in those regions except mount Goranto, the ancient Chimera, in Lycia, the foot of which is washed by the Mediterranean: its head, which is very lofty, still emits smoke and sparks, and sometimes flames. It seems by what we learn from a passage of mythology, to have been reduced nearly to this state in the heroic and fabulous ages, that is to say, more than five and thirty centuries ago.

§ 25. Where this means of discharge is wanting, for it is not always to be found, it has sometimes happened that these internal fires, from the excess of their fermentation, have forced the ground where it was weakest, and

that the fluid matter has made its way to the surface of the earth, and overflowed it more or less. There could be no difficulty in expelling the lava through this level orifice, whence it must spread ; but it cannot find a sufficient issue to spend itself ; for it cannot run off on a plain as on the declivities of a burning mountain : the position of the mouth, whence it proceeds, obstructing its progress, it can discharge itself but feebly. This will appear still more evident, when we come to describe, *Section 66*, the slow and difficult manner in which lava is disgorged even from a crater very elevated. The air having time to act upon it, this superficial mass gradually cooled, consolidates the ground it has covered, renders it more secure, and prevents the opening of any new mouth thereabouts. This, I think, is the origin of certain spots of ground known by the name of burnt plains.

Although the lapse of ages must have disguised the ancient aspect of many plains, which had been overflowed by lava thus discharged, we are acquainted with some that are very

distinguishable. To the burning soil of Pamphylia, not far from mount Climax, the only place where the fire appears to have preserved some passages, according to our observations in *Section 15*, we shall add a large tract of country, which is said by D'Anville, as well as by Strabo, to extend from Mysia to Phrygia, and which they also tell us was very subject to earthquakes: the ancients called it *κατακεκαυμένη*, or the burnt country.

There are two other plains which have been rendered famous by the same fires. That of Phlegra in Macedonia, in the Peninsula to the South-east of the mouth of the gulph of Thessalonica, opposite to some little islands, which, as well as Lemnos, at no great distance from them, were once on fire. The other lies between Pozzuolo and Cumæ, in Campania, extending to within a few miles of Vesuvius. These places were very much frequented. As the ancients perceived nothing externally that indicated the cause of their burning, the state in which they appeared was attributed by the Greek and Roman mytholo-

gists, to a shower of stones rained by the Gods. They said the same of the plain of *La Crau*, near the eastern mouth of the Rhone—but the stones with which it is covered are all detached, have not been burnt, and lie upon a very deep, sandy soil. They are smooth flints (*cailloux roulés*) which have been carried along and left on this extensive region by the river Durance, in its course through it, which has since been changed: whereas, the very soil of the two first-mentioned plains is burnt deep, and horridly cracked, and all the stones upon them bear the marks of fire. The ancients have therefore described them under the expressive denomination of *Campi Phlegræi*, that is to say, burnt fields.

CHAP. VI.

*Are all mountains produced by subterranean fires?
Are not the burning mountains at least produced
by them? Proofs of the conflagration being
posterior to the formation of the mountain.*

§ 26. **SOME** authors have advanced, that all mountains were thrown up from the bosom of the earth by the violence of subterranean fires: an hypothesis which appears to me to be overturned by the two following considerations. In the first place, every substance on which fire has acted must necessarily bear the marks of it, which is by no means the case with far the greater number of mountains, being peculiar to the shell of those that are burning, or that have been burnt. In the second place, eminences produced by fire, for there are certainly some, of which we shall have occasion to speak, independently of the exterior marks of it, are

compounded of all kinds of stones, broken, of different sizes, half calcined, amalgamated with vitrified sands, and mixed with parched earth. How easy is it to distinguish them from common mountains, which almost all consist of regular and similar layers? So generally is this the case, that the greater number of naturalists, far from attributing their formation to the action of fire, which is always violent, sudden, and disorderly, have, on the contrary, with much more probability, maintained that the mountains were produced by the slow, constant, and regular motion of the waters of the sea, and that in the course of time by fortuitous causes fire had made its way into some of them.

The question respecting the origin of mountains, still is, and long will be, problematical in physics. This was the opinion of one of the most learned naturalists, Mr. Pallas, who in his speech to the Imperial Academy of Petersburg in 1777, passed an eulogium on the author of *The Enquiry respecting the Americans*, for having said, that one might as well write a treatise on the formation of stars, as on that of moun-

tains, which were raised by the hand of the Creator.

§ 27. Other authors, some of whom are of the highest authority, adopt a medium between the two assertions. They divide mountains into two classes, and affirm that all volcanic heights are throughout the productions of subterranean fires. It is understood that we are not at present considering the causes of the conflagration of a mountain, which is ascribed absolutely to those general fires by Dr. Woodward and Dr. Hutton, to pyrites alone by Dr. Lister, and recently by others to electric matter. I have already stated my own opinion on the subject, and admitted the probability of these three causes acting separately. But the question now is about the mass itself of volcanic mountains, which several naturalists suppose to have been raised by the action of subterranean fire. I know not how this opinion can be reconciled with the date of the creation, even though we adopt the chronology that carries it the farthest back : for, although we know that islands have been almost instantaneously produced, and by a continued effort

of fire raised some hundred feet above the level of the sea, we cannot thence conclude that a similar effort has produced the almost perpendicular peak of Teneriffe. So prodigious an elevation could not have been raised but by innumerable accumulations of new matter. But it is a known fact, that nothing that comes from a volcano on land* contributes to an additional permanent elevation of it. All that is not thrown to a distance, falls back, or flows to the base and enlarges it. Can nature then have changed the course of her operations?

§28. But not to insist on this argument, which it is not so easy to answer as to elude, by supposing that the first eruptions of the subterranean fires, from the abundance of matter, must have had effects far beyond what they can at present produce in the exhausted state of the stores of nature; it seems to me that our former observations are enough to subvert this hypothesis, as quarries are found opened in the external bases

* The author's expression is, *à découvert*, which he uses throughout this Treatise, to distinguish volcanoes on the face of the earth, from submarine volcanoes.

of several volcanic mountains in strata; like common stone, or in lumps like granite: for as Dolomieu, one of the most distinguished naturalists, observes, "It would be difficult to mention any kind of stone forming the base of a mountain, that would prevent it from breaking out into a volcano; as every sort of rock may help to form volcanic productions." It is however generally agreed that volcanoes more commonly generate in granite mountains. This is the opinion of Mr. Desmarets, as expressed in the Memoirs of the Academy of Sciences in the year 1771; of Mr. Pallas, in the speech I have cited above, in which he asserts that all the greater mountains of the world are of granite; and of Mr. de Saussure, who, in his 5th chapter, section 181, calls granite mountains *the cradles of volcanoes*. Father Della Torré, well known by his writings on Vesuvius, talks positively of having ascertained that granite was the original base of that mountain. Now, regularity in the beds of stone, or in the situations of the lumps of granite, and the uniformity of those matters, seem to overturn entirely the notion of a mass

violently agitated by fire in the bowels of the earth, previously to its being vomited upon the surface. Besides there are volcanoes, the fire of which attacked only a part of the mountain, the rest of it remaining untouched. This kind of volcanoes probably had no long duration : but of what importance is the number of centuries they existed ? It is enough that they have existed ; and it is impossible to deny, that the origin of the part attacked by the volcanic fire was coeval, and formed a whole, with the part which remained in its primitive state. To give one instance out of many that might be cited, I shall mention a high mountain, called *La Bannière*, four miles from Riom, in Auvergne. All the North-east part of it has been consumed for near a league in length : the side and foot are covered with an immense quantity of burnt rubbish, which the lapse of ages has not sufficed to bury entirely, and still less to alter from its nature. A prodigious and deep funnel, a part of which only remains, the rest having evidently fallen into the abyss, shows by the calcined state of the rocks which form it, that the mouth

of the volcano was there. In walking along the ridge of the same mountain to the South-west, without either ascending or descending, there will, no doubt, be found scattered on the surface a quantity of baked masses, pumice, and burnt sand, the remains of the eruptions of its volcanic part; but on removing these scoria, this side will appear not to have been attacked by the fire. It consists of coarse granite, in natural lumps, like those in the adjacent mountains, where there has been no fire. The inhabitants are continually taking it up for building; and they dig the lava at a little distance, to use it for ornament. It is probable that this mountain was originally a complete one, of which one part, in the course of time, began to burn: consequently, that the fire was produced in the mountain, and not the mountain produced by the fire.

CHAP. VII.

Are all volcanoes formed under the sea? The reasons that have given rise to this hypothesis discussed. The characteristics that distinguish volcanoes from the general subterranean fires.

§ 29. MR. HOUEL, an author well known for his various inquiries, particularly into this part of natural history, is also of opinion, in his picturesque travels, in the islands of Sicily, Malta, and Lipari, four volumes in folio, Paris, 1782, that the volcanic mountains are all produced by the subterranean fires: but, observing that a volcano, when it has once risen above the sea, no longer makes any sensible increase, and that it is only under water that volcanic elevations are, or can be, enlarged; he concludes, that volcanoes can only have been formed in the midst of the sea. This opinion is made more plausible, as we find, by its eluding a difficulty raised by

the very nature of things. We shall see in the course of these pages, when we come to treat directly of submarine volcanoes, how very slowly and feebly they increase. This Mr. Houel acknowledges, and of course does not hesitate to allow, that such productions require the lapse of many ages.

According to this theory, all volcanoes, even those now at the greatest distance from the sea, as well as those that raise their heads the highest above its level, must, from their base to their present crater, have been formed beneath the water.

Now, in the first place, what an immense series of ages, for example, must be allowed for the formation of Cotopaxi, in Peru! The exterior base of that volcano, and the plain on which it stands, are nearly 2200 yards above the level of the Pacific Ocean, and its elevation from this base is about 3600 yards more. The whole of the latter height then, at least, must have been the effect of the volcanic action. In the second place, although it is allowed that the sea sinks, a fact easily to be proved, what an-

other prodigious number of ages must have elapsed, by this hypothesis, from the time when the sea, after completing the last accretion of Cotopaxi, began to descend from the crater of it, till, by an insensible reduction, it fell so low as 5800 yards, or more than three miles and a quarter, below the original level ! This accumulation of ages alarms, but does not dishearten Mr. Houel. " The elevation of a volcano, says he, (vol. ii. page 89,) requires a succession of " innumerable ages." And a little after ; " The " time necessary for the formation of these accretions, and for the lowering of the sea to " its present level, raises a calculation that " frightens me, when I observe how slowly " nature effects these great revolutions." He again says, in vol. iv. page 67 ; " Ages upon " ages, without number, have passed while Sicily " was insensibly growing under the waves : it " then appeared like a point on the surface of the " sea, and succeeding ages saw it magnified, " and making a part of the solid earth."

We are not to consider these ideas and expressions as exaggerated ; they are accurate and

just in Mr. Houel's system : certainly nothing less than an immense succession of ages was necessary for such productions by such means.

But supposing that a succession of innumerable ages had elapsed ever since the formation of the world, with which that of volcanoes can at most be but coeval ; all the original mountains that have not been produced by fire, would by this time be level with the plains, and we should have no springs nor running water on the earth, because every eminence daily loses something of its mass, which increases the lower regions, whence in time a general level must be produced. Some slight risings, thrown up by agitations at different times, form no objection to this : we do not find that they increase, their production, therefore could never counterbalance the losses to which the others are doomed by the laws of nature. There is no other hypothesis, therefore, which I would not prefer to this, of an innumerable series of ages, for the formation of volcanoes. The actual state of things is repugnant to it : besides, the opinion of a fortuitous communication of fire to the bowels of

certain mountains is so simple, and so well grounded on all we see, that it appears to me a needless labour to seek farther.

I am very much inclined to believe, that among the volcanoes which have opened in the last two centuries, (*i. e.* the 16th and 17th,) and some of which are mentioned in this work, together with their dates, several are only old ones revived. I have ventured to declare this suspicion, as I have been led to it by the nature of the places. But why should we not suppose that some of those mountains have lately become volcanoes for the first time? There is nothing incongruous in the admission of this fact, nor do I find that it ever was called in question. Why then recur to extraordinary systems, to explain the formation of former volcanoes?

§ 30. The reasons given by Mr. Houel are, that the surface of Etna is now nothing more than a crust, like that of a pie over an empty dish; that this crust has been entirely the work of fire, and that marine substances are found deposited in it as far up as a quarter of its height at least. These, I believe, are the principal argu-

ments in support of this opinion, which in his great and elegant work is displayed in the most engaging and ingenious manner.

Without combating the author's assertions, may it not be said in the first place, that volcanoes, in a state similar to that in which Etna was seen by Mr. Houel, are very rare, and of course that the arguments do not hold good as to the greater number ; that Etna, and perhaps a few others, appearing as exceptions, their state cannot be a rule for a general inference, as it has been made by this author ?

But in the second place, may there not be a mode of accounting for this state of Etna, and the other few, so probable as, instead of leaving them exceptions, shall reinstate them in the more simple system of fortuitous conflagration ? Would there, for instance, be any thing marvellous in supposing that the fire had in the course of time consumed all the original rock of Etna, and reduced it to the present crust, consisting in fact only of the matter so repeatedly vomited by this volcano ?

As for the marine substances deposited in the

mountain, what do they prove but the incommensurable depth and capaciousness of this burning gulph, to use the energetic expressions of Mr. Houel, which, extending far beneath the sea, must often have ejected through its crater, or its gaping flanks, masses more or less digested, in which such substances may be met with ?

One observation more, on these various opinions, before we return to the main points of our subject. Were all burning mountains thrown up from the bowels of the earth, we should meet with volcanoes of all heights, from the various degrees of the strength of the internal fires. Nay, the smaller hills would be more liable to volcanic eruptions. This observation is so strongly founded in the nature of things, that it is unnecessary to dwell upon it. Now, no volcanoes have opened on small hills ; on the contrary, they have all broken out at the loftiest summits of the earth.

§ 31. Before I enter upon the proof of this observation, I must remark, that, notwithstanding the similarity between several phænomena of

the general subterranean fires and those of volcanoes, the latter have a peculiar character, by which they are essentially distinguished; and that is, a fixed mouth for the issue of the fires, and the emission of matter fermenting in the abyss, which forms their reservoir. This mouth is always open in volcanoes that have broken out in mountains above the sea, and burning: it opens and shuts in submarine volcanoes. This circumstance does not always attend the subterranean fires, but if they casually take it, as I have explained in § 7, and § 24; in that case they become peculiar, quit their original class, and are denominated only volcanic fires, whether they are in open burning mountains, or shut up under water. This is a received acceptance, to which we must adhere in order to be understood.

CHAP. VIII.

All volcanoes above the sea occupy lofty heights.

Their elevation is still more evident in islands.

Of the fires formed at the foot of a volcano.

The cause of the elevation of volcanoes on land.

§ 32. **W**E have seen in the preceding chapters that there are no volcanoes in plains; that it seems to be impossible that a mouth opened on a level surface, after vomiting lava, should continue open for new emissions; that such a mouth necessarily chokes itself up, and that the consequence is, that such plains in future are of all the parts of the vault that cover the internal fires, the most impenetrable.

We shall here add, that the volcanoes which are, or which have been open, have always taken possession of the heights, and commonly of the

loftiest heights, in whatever regions they have appeared.

The part of the world where the greater number of volcanoes are found is the highest; namely, the chain of the Cordilleras. Those that have been extinguished there are far more numerous than those that are burning; still there are a great many of the latter, as will be seen in the enumeration I shall make in a future section of all the volcanoes known; and it has been constantly observed, that in the immense continuity of that chain, the volcanic heads have always been the highest. On the coast of Alascha, in North America, lying between the latitudes of 55 and 57 N. Captain Cook discovered mountains of an extraordinary height, one of which threw out clouds of smoke. Don Maurelle, in latitude 59 of the same coast, perceived on the 3d of August 1779, a mountain at that time all covered with snow, which actually vomited torrents of flames; and which was thought to be higher than the peak of Teneriffe.

In Asia, the mountains of Ararat, Chimera,

Olympus, Amanus, Casius, and other summits, that have been on fire, are the most elevated in the chain of Taurus. The volcanoes which are burning in Kamtchatka, are the highest of the mountains in that vast peninsula. Kamtchatka, in lat. 56, long. 176, is seen at the distance of 397 verstes, near 300 leagues, although the country is very mountainous. It took the observers who accompanied M. de la Peyrouse, three days to reach the crater of St. Pierre d'Awatcha, owing to its steepness and height.

In Africa, the kingdoms of Congo, and of Angola, are divided by a chain of very high mountains, of which so great a number have been on fire, that according to Varenus, chapter 10, of his *Universal Geography*, they are known only by the name of *Burnt Mountains*.

In the *Periplus of Hanno*, whoever be the author of it, mention is made of a very high mountain on the continent of Africa, near the latitude of the Canaries. Its head, says the text, was lost in the clouds; and it vomited torrents of burning matter, with the quantity of which the plain below was covered. The Car-

thaginian fleet was then off the coast, and had it in sight. The interpreters whom Hanno had with him, called this volcano, *The Car of the Gods*, *Θειον οχημα*. It is now extinguished, and I have not found the vestiges of it noticed by any author. When the interior of this quarter of the world is better known, it is probable, from its being so loaded with very lofty mountains, that many volcanoes will be met with in a similar state.

In Europe, Vesuvius, which appears to be considerably injured, remains still nearly equal to the highest point in Great Britain, Bennevis, in Scotland: Vesuvius is almost 4000 English feet high, and Bennevis 4370. There are a great many tops which have been on fire, from the Bolognese to the bottom of Calabria, all of which are remarkable for their elevation in the chain of the Appenines. The most mountainous provinces of France, Auvergne, and Upper Languedoc, have been covered with volcanoes.

§ 33. The extreme elevation of volcanoes is common to islands as well as to the continents of the two hemispheres. It is even more re-

markable, for every island is of itself an elevation from the ground at the bottom of the sea, which is to be added to that of the crater above the level of the sea. For example, calculating the height of the peak of Teneriffe, from the level of the ocean, it is already considered as the loftiest summit of the eastern hemisphere : now, this mountain, which is in fact the island itself, rises out of the Atlantic, where the ocean is said to be the deepest; what an immense distance then is presented to the mind by this idea, which, with hardly an exception, is common to all insular volcanoes, between the mouth of the volcano, and the bed of its fires ! Almost all the lofty peaks in the Azores have been on fire, and several are still burning : Varenus asserts this in the chapter already cited, after having reckoned them and Hecla, in Iceland, in the number of the loftiest points of the earth. Etna is but little lower than the peak of Teneriffe. Mount Souffriere, in Guadaloupe, and mount Misery, in St. Kit's, are the highest mountains in those islands. The smoking mountains of Dominique and Nevis, are also very high, as we are told by

Mr. Bryan Edwards. The three mountains that have been on fire in St. Lucia, those in Martinique, and the other islands in the gulph of Mexico, which bear the marks of fire, are also the highest points. The volcano in the isle of Bourbon, is of a very great height, and very difficult to be approached, according to M. de Commerson's circumstantial description of it. Of the three peaks of this island, all nearly as high as that of Teneriffe, the one most to the South-east is the one on fire. The peak of Adam, which is in the centre of the island of Ceylon, vomits fire, and is reckoned among the highest mountains of the globe. Not far from the foot of it, is a large field where the poppy, from which opium is made, grows in such abundance, that if a man fall asleep in it he wakes no more; for the air is so impregnated with narcotic miasm, that it becomes a poison to man. In the Philippine Islands, in the Moluccas, Marianas, and Carolinas, the same observation holds. So it does at Java and Sumatra. The Fesi, in Japan, is said to exceed Etna in height. The *Otoa*, or divinities, as the

inhabitants of the Friendly Islands call volcanoes, are all very high, as we are informed by Captain Cook. In an island farther to the northward, that celebrated navigator saw one, the height of which seemed to surpass that of Cimborasó, which is certainly the highest mountain of either continent. To conclude, with an authority which, perhaps, it would have been sufficient to have cited alone, when we consider the discernment and learning of the author, Doctor Forster, in his *Observations on his voyage round the world*, asserts, that it is always the highest islands which are found burning, or which have been in that state.

§ 34. There is a kind of fire, which we did not mention when we were taking notice of those that are different from the volcanic ones, because, in fact, they should not be distinguished from them. Amidst the convulsions of a volcano, fires have been seen issuing from beneath the adjacent plains; and it has even sometimes happened, that a part of those plains has been ingulphed. In the course of the calamities that happened to Peru, in February 1794,

such casualties took place in several parts of the province of Quito. In the grand eruption of Etna, in May 1537, of which we have a description in Fazello, the earth, after a dreadful convulsion of eleven days, opened in divers places, even at the distance of fourteen or fifteen miles from the volcano, and vomited torrents of fire and smoke, which made terrible havock more than five leagues round. Disasters of this kind are unhappily but too common; and proceed from the fires of the volcano, that make their way through the more feeble parts, which roof its burning pit; or that, having undermined the supporters of those parts, occasion the falling in of the earth.

When the mountain is very high, and of immense bulk, like Etna, the peak of Teneriffe, and several others, diminutive cones are found at various heights on its sides, in the form of small volcanoes, some of which emit smoke and sparks through their crater. Sir William Hamilton, from the top of Etna looking towards Catania, counted more than forty of them on the prodigious flank of that volcano. These

are manifestly the effects of the effervescence of the lava, which, from being too much restrained, has forced those weaker parts, and formed a kind of spout. But it is clear, that these accidental mouths borrow their fires solely from the principal pit. In the eruption of Vesuvius in 1794, a similar cone was formed on the declivity of the mountain, and was nearly two hundred feet high : some persons with great difficulty climbed to the top of it, which was open, and a sounding line being thrown in, no bottom was found, that is to say, it had no other than that of the volcano. What is more extraordinary still, these tops, so much lower than the head of the mountain, have been seen vomiting lava, when none came from the principal crater. This must be owing to there not being a sufficient quantity of matter dissolved in the bowels of the volcano, to rise so high ; and it must then of course pour through the lower mouths. None of these accidental matters, then, overturn our assertion, that volcanoes are always very high mountains. So the cedar and the cotton-tree have low branches, but it is the trunk which

constitutes the tree, and from that its height is estimated.

§ 35. This constant elevation of all volcanic mouths which are above the sea, shows that it is the effect of necessary causes. We have, in fact, seen that their fires may have two different situations: that they either proceed from a reservoir concentrated in the womb of the mountain, where they are fed only by the stores of combustible matter it contains; or, that rising from a distant pit, and particularly from immense furnaces, which at a vast depth are continually acting upon the bowels of the earth, they set the mountain on fire through passages, which they find, or force open under its base, or in the great descent of its sides.

Now these two circumstances require equally, that the mountain to be set on fire should be of a superior order; in which expression I include indifferently the primitive mountains, and those of a later formation, for we see the fire flying equally to the tops of either.

Mountains, like all the other productions of nature, have a regular conformity of parts: the

dimensions of their mass are in due proportion : I mean that we may always estimate the width of the sides, and the depth of the base, by the height to which the head of a mountain rises on the globe. The exceptions to this rule, for there are some, are very few in number.

We may add, that, of course, all the internal properties of which a concurrence is necessary to the forming of a volcano, such as fissures, caverns, a variety and abundance of inflammable matter, and a quantity of air and water, all in that case preserve similar proportions.

According to these plain observations, we shall not find in a mountain of an inferior order, either bulk sufficient to contain and put in action what is necessary to produce a volcano of the first kind, which I have just mentioned ; or depth enough for its base to reach, and still less for its sides to attract, the interior fires, commonly called *central*, and give existence to a volcano of the second kind.

But we can conceive without difficulty, that the summit of a very high mountain, which in its descent takes an extension always increasing,

probably down to its extreme internal base, may become a volcano either way. Etna extends itself nearly beneath the whole island of Sicily: what a prodigious lateral expansion, what dimensions at its base must it have when it reaches its lowest internal foundation! As to its depth, we must suppose it very great; but where shall we presume that it stops?

If we consider the peak of Teneriffe, only from its summit to the level of the Atlantic ocean, how is it expanded even in that descent! Yet that is but its apparent base on the surface of the globe. Could we follow it to its interior foundation, how should we be astonished at its extent and depth?

It is easy to conceive, that nature may either convert such prodigious masses into formidable arsenals; or employ them as fire-pumps in throwing out the subterranean fires, in order to relieve the bowels of the earth, and prevent a confusion over the whole surface of it.

I admit that all volcanoes are not so high as Etna, or the peak of Teneriffe; but we may consider these two as holding nearly the middle

point on the scale of volcanic mountains. Many volcanoes are of their height : they are about a third lower than the highest, and certainly very few are a third lower than they are.

CHAP. IX.

The volcanoes of the Moon have eruptions equal to those of the volcanoes of our globe. That planet abounds with very high mountains.

§ 36. AFTER these reflexions on the very elevated positions necessary to volcanoes, we shall be less surprised at the result of the discoveries of the intelligent Herschel, respecting the volcanoes in the Moon.

It had, before his discovery, been suspected that there were some in that planet. The luminous and blazing point, of the size of the diameter of a star of the second magnitude, which was perceived in the Moon by Don Antonio de Ulloa, and other observers, who were on board his ship, near Cape St. Vincent, during the eclipse of the Sun in June 1778, and which that philosopher judged to be a part of the solar disk itself, that became visible by means of an

opening which extended through the Moon, from one side to the other, had been presumed by other naturalists to be simply a volcano, in the state of eruption on the Moon; the fire of which, from the circumstance of the eclipse, and the casual position of Don Antonio's ship, had appeared stronger to him.

On the 4th of May 1783, Herschel discovered a volcano, which was ejecting flames; and on the 19th of April 1787, he distinguished three, one of which was then in full play. The astronomer, by means of the perfection to which he has brought the telescope, succeeded in ascertaining the dimension of the diameter of the body of fire that rose from that volcano, and found it three miles.

This effort of nature is equal to that employed in the largest of the volcanoes of the earth, and consequently bespeaks in the respective heights an approximation, which one would be induced to reject, were one to consider only the difference of the diameters of the two planets.

Herschel allows a height of two hundred leagues to the inequalities, or mountains, on the

solar ball, the diameter of which is to the ball of the earth, as ten thousand to one hundred and four and a half. Now, the diameter of the Moon being to that of the earth, in round numbers, only as seven to twenty-six, its surface as fifteen to two hundred, and its solid bulk as one to fifty, were we to suppose, that the elevation of the mountains on the two planets was proportional to the diameters of the respective orbs, the mountains of the Moon would be more than three times as low as those of the earth; in which case it would be unlikely, that there should be on the former planet volcanoes of the same force as those on the latter.

§ 37. But it has been discovered, that the Moon, notwithstanding its deficiency in those primary proportions, is covered with a prodigious number of mountains, of a height approaching ours. It is known that we never see more than a half, and always the same half of the lunar disk: yet on that surface, so small in comparison with the earth's, Herschel has reckoned more than four hundred mountains, of which he judges several rise 3000 yards upon the face of

the orb. Had the ancients any mode of supplying the knowledge gained by our telescopes, as it has been suspected by Mr. Dutens, or did their penetration sometimes serve instead of them? It is very astonishing to find in Stobæus, that Democritus affirmed, that the spots on the Moon were only the shadows of the very high mountains of that planet. Stobæus lived in the fifth century, and Democritus nine hundred years before him.

Since the observations made by Mr. Herschel, Mr. Schroeter of the Royal Society of Gottingen, who is also a very distinguished astronomer of our times, has shown in his *Savante Sélénographie*, (Description of the Moon) that several of the mountains of that planet are higher than those of the earth. Among others, he gives the mountain called *Leibnitz* twenty-five thousand feet, that is more than eight thousand yards.

Shall I dare to allow myself a reflexion which goes farther, and assert, that if our mountains were measured as those of the Moon are, it would appear, that, a very few solitary peaks excepted, the grand heights of our globe would

be reduced to three thousand or three thousand six hundred yards at most. I will explain myself without delay.

In order to know the absolute height of our mountains, as well as their relative heights with one another, it was certainly a very good idea, to take for a common level that of the sea. I know, that, according to this rule, many summits in the Andes rise from five to six thousand yards above that level : but the question at present is, respecting the proportion between the mountains of the Moon and those of the Earth. The height of the former were taken in a different manner, and through necessity from the bases whence they rise, because we have no sure intermediate level on the orb of the Moon, like that which the barometer gives us for the earth. Now let us suppose, that we were obliged to measure the peaks of the Andes, or those of Altai, from the Moon, which has no ocean ; we should begin at the immense plains whence those peaks shoot up as from their proper bases, and consequently we should occasion them to lose in the computation of their real height, all the elevation of

those plains above the level of the sea. Thus, the numerous peaks which line the vast plain of Quito, would lose at once the 2200 yards which that plain is certainly raised. The peak of the Altai would, perhaps, lose more, to judge of the height of the plain on which they stand by its natural state, and according to the calculations of Father Verbiest, who makes this plain six hundred leagues in circumference, and an astronomical league in height, above the level of the Yellow Sea, or Sea of Pekin.

Here we should manifestly lie under a mistake, from a very considerable, though undesigned, reduction. Who shall insure us from not falling into a similar error, in determining from the earth the height of the mountains of the Moon? They are certainly as high as we say, but it is very possible, and even probable, that they are higher.

This conformation of the Moon, in regard to the number and height of its mountains, accomplishes more fully one of the designs of the Creator in the production of that planet; as by

that multitude of great inequalities it reflects more light upon us. The knowledge of this conformation, added to that of the great cavities discovered on it, from which we are justified in supposing many internal ones under its mountains, puts at the same time an end to our surprize, at finding on that planet volcanoes as great as those of our earth.

Let us remark, by the way, that the existence of volcanoes in the Moon has demonstrated, that it has an atmosphere, which had hitherto been generally denied. Thus discoveries made in the Heavens convince us, that there is a greater affinity between the nature of the planets and that of the earth, than from habit we were disposed to allow: for example, since it has been clearly shown, that the part of Mars which experiences winter is regularly covered with white, while the opposite side, which has summer, appears clear; and that on the change of seasons, the same parts take the contrary appearances; it has been concluded, with every probability, that the seasons are

established on that planet, and most likely on the others, and attended with effects similar to those they have on our earth; except, however, the difference necessarily resulting from that of the inclination of their axes.

CHAP. X.

The striking contrast between the great elevation of the volcanoes on land, and the lowness of the submarine volcanoes.

§ 38. **ALTHOUGH** we have confined our assertions and proofs respecting the great height of volcanoes, to those on land; the reader has seen that we have no intention to exclude the mouths of fire, which alternately open and shut under the sea.

This alternate opening and shutting, necessary to their preservation, and the singularity of their situation, being almost the only characteristics which distinguish these fires from those on land; they have been all classed under the general name of volcanoes, only using the word *submarine* when speaking of a volcano under the sea. It seems proper, that we should here attempt to explain the causes of such an

extraordinary position as that of the submarine volcano, and of so marked a contrast as that between the extreme elevation of those on land and the lowness of these, even below the level of the ocean. But we judge that it will be more regular to treat separately of all that relates to the latter. The very interesting circumstances peculiar to submarine volcanoes seem necessarily connected. It is, therefore, a distinct task which we will endeavour to perform, after we have gone through, as well as we can, all that relates to the volcanoes on land.

CHAP. XI.

Islands rendered uninhabitable by their volcanoes.

The singular state of Iceland, in respect to its fires, and the heat of its waters. The means of discovering the cause of the heat of hot springs. These waters begin to boil in less time than common cold water.

§ 39. **T**HERE are islands of a moderate size, which the almost constant working of their volcanoes renders uninhabitable, such as that of Amsterdam, of which we have already spoken, on account of the exhausted state of its volcano. That island is only seven leagues round. The fire appears to act throughout it with inconceivable violence. We have before seen, § 14, what Mr. Eneas Anderson reports of the excessive heat of its springs. It is in truth nothing more than a desert mountain, burning by itself, in the middle of the ocean.

The Portuguese have made several attempts to form establishments in the Island of Fuego, one of the Cape de Verd Islands; but the frequency and violence of the eruptions of its volcano, and of its earthquakes, have always compelled them to leave it.

The island of Borta, one of the Moluccas, has a volcano in the middle of it. The island was formerly well cultivated. A prodigious ejection of lava from the top of the mountain, flowing all round, took place towards the end of the seventeenth century, 1698, which covered the whole island. All the inhabitants were destroyed; and Borta has been ever since an enormous barren rock, from ten to twelve leagues round, an immense Pharos in that part of the ocean.

Among the Ladrone, or Mariannas, the islands of St. Antonio, St. Francis, the great Volcano, St. Denis, and Assumption,—I name them according to their proximity to the line,—are all rendered nearly barren by the different overflowings of their volcanoes. That in the island of Assumption is very remarkable in one respect, as observed in the part of M. de la

Peyrouse's Voyage which is published, and that is, that the inside of its crater is covered with a glass of a sooty black.

I shall here refrain from particularizing many other islands, scattered over the world, that are in a similar state to the foregoing, such as the abovementioned island of Volcano, sixty leagues due South of Jeddo; one of the Likayo; that of Kao, in the Friendly Islands, and several of the Ladrone; in order that I may dwell a little on two, which, from the prodigious abundance of their fires, and the singularity of the phænomena attending them, must attract the observation of those who are interested by this part of Natural History: I mean the island of Iceland, and Kamtchatka.

§ 40. Next to the islands that are rendered uninhabitable, there is not perhaps one more agitated by its fires than Iceland. Besides Hecla, M. Valmont de Bomare reckons there five other volcanoes emitting fire, namely, Æcraise, Krafle, Portland-boukt, Westeriækcl, and Kotlegau. Æcraise, or Oraife, as it is called by Horrebow in his Natural History of Iceland, chapter 7,

vomited flames in 1724. According to the same author, Krafle had eruptions almost constantly from 1726 to 1730, and Kotlegau had a violent one in 1721.

In June 1783, it was feared that this island would fall to pieces; and it was even reported for some days that it had been swallowed up, so dreadful and multiplied were the convulsions produced by its volcanoes and internal fires. A thick, sulphureous smoke rendered the island absolutely invisible to mariners at sea, while the people on shore were all in danger of being suffocated by it: and in fact a number of men and beasts died in consequence of it. The fog which about that time spread all over Europe, was considered as an effect of those exhalations. *See* § 61. Frightful hollow roarings proceeded from the bowels of the earth, and from the bottom of the sea. From mount Shaptan-Gluer, a seventh volcano in the island, there poured a terrific torrent of fire, which flowed for six weeks. It ran a distance of sixty miles to the sea: its breadth was nearly twelve miles; and in its course it dried up the river

Shaptaga, which in some places is thirty, and in others six and thirty feet deep. These particulars were published at the time, and they have been confirmed by Mr. Stanley, in his excellent Memoirs. This gentleman has visited Iceland twice since the year 1789, for the express purpose of making himself acquainted with that interesting island.

It is of considerable extent, forming a parallelogram of about 264 miles in length, and 150 in breadth, containing a surface of 13,200 miles. Had it been smaller, it would, in all probability, have been no longer in existence, but would have been swallowed up by the ocean; whence Vontroil, in his Letters on Iceland, supposes it to have risen. Almost in every part of it sulphur is collected on the surface of the ground, and is inexhaustible, especially in the North-east of the island, where mount Krafle is situated. Horrebow, who spent several years in Iceland, assures us, chap. 18, that at many places eighty horses may be loaded with it in the course of an hour, each horse carrying two hundred and fifty pounds. He agrees with Anderson, that, not-

withstanding the great number of burning volcanoes, there are twenty more in Iceland which are extinguished. A great part besides of its level ground stands over abysses of fire. According to the last mentioned authors, the little town of Myconfu and its environs were swallowed up in 1729. These fiery abysses run out under the surrounding sea, and there keep up a submarine volcano, as we shall see, by and by, when we come to treat of that kind of volcano. It was that volcano which, in 1783, produced, amidst the boiling waters of the ocean on the South of the island, a number of small cinder islands, which have since one after the other disappeared.

On no part of the earth are hot springs at present found in more abundance than in Iceland. In a space of two miles round Mr. Stanley reckoned more than two hundred boiling springs, several of which were very large. Most of them spring twenty, thirty, and forty feet into the air. That of the new Giezer throws itself up even a hundred and thirty feet, with inconceivable rapidity. Several of them intermit, and among others the

last mentioned. The time of intermission is from five to twenty minutes, rarely more. Every time that an eruption of the new Giezer takes place, the adjacent ground is violently shaken, and a dead noise, resembling a brisk cannonade heard at a distance, strikes those that are not accustomed to it.

The inhabitants frequently dress their meat and all their victuals in the water of the Giezer, and in many other springs of the island ; which are almost all warmed by the fires of the volcanoes.

The Court of Denmark, on the authority of its historians, and the documents of its archives, is convinced that between Norway and what is now called *New Greenland*, there was a large country, which bore the original name of Greenland. So strong were the proofs of it in the opinion of that Court, that a few years back ships were sent to sea to go and look for this country, or to discover at least some vestiges of its existence. They met no success. It seems that the land was entirely swallowed up. Is it probable that a similar fate awaits Iceland?

Does the long continuance of the state of things give grounds for apprehension or reliance ? An author of the eleventh century, Saxo Grammaticus, in his History of Denmark, speaks of the boiling springs of Iceland, as they are known to us at this day.

§ 41. The great degree of heat in the multitude of springs that are produced in Iceland ; the remarkable number of them in the peninsula of which we are about to speak, and their being common principally in regions where there are or have been volcanoes, naturally lead us to the means of investigating the indications by which we may gain a knowledge of the origin of the heat of hot springs ; when we may presume that they borrow it from the internal fire, and when from the action only of minerals.

No one will confound the waters, simply mineral, with those of which we are treating. There are substances, which, without communicating any warmth to the waters that wash them, impregnate them with properties according to the nature and quantity of those substances : these are the waters *simply mineral*.

There are hot springs which differ from common springs in nothing but their heat : these are *simply hot springs*, and are very rare. Those which, with their heat, possess also medicinal or pernicious properties, are called *mineral hot springs*.

It is also very possible, that there may be waters which, after being heated under ground, no matter by what means, lose their heat in the long windings they make before they appear ; but as they issue cold at their spring, they are not connected with the present subject.

The following considerations will, I think, suffice on most occasions to determine the origin of the heat of waters.

1st. Springs simply hot, but not mineral, derive their heat from an active fire, and not from minerals ; because every mineral that gives a marked degree of heat to a liquid, must necessarily have also some influence on its quality. Water coming in contact with the mineral, causes it to undergo a dilatation, a decomposition, and consequently to suffer some loss. It is the strength and abundance of these

emissions received in the body of the liquid, which, by their motion, cause the heat. These detached particles are infinitely attenuated, say to the degree of the emanations of amber or even more: as those electric emanations are found in the air which is impregnated with them, and the odour of the amber is perceptible in it, so those mineral parts would be found; and more easily still perceived by the taste, or by analyzing in the water, which is a denser medium than air, if the heat of the water were really owing to them: whence I think we may infer that all springs simply hot take their heat from an active fire.

2dly, If the water of a hot spring when analyzed yield neither iron nor sulphur, it does not owe its heat to minerals, but, whatever qualities it may farther possess, it owes it only to an active fire; for we know of nothing but fire itself that can cause it where there is neither sulphur nor iron; and on this ground there has been reason to conclude, that the waters of the new Giezer were heated directly by the internal furnaces of the soil; because on being analyzed

by Doctor Black, they yielded neither iron nor sulphur.

3dly, An extreme degree of heat in the spring also indicates the same origin. For example, the water of Giezer, which we have just cited, is at 212° ; and that of the island of Amsterdam much higher. Sir William Hamilton mentions a spring near Solfaterra, which also has the heat of boiling water; and another near lake Avernus, not far from Puzzuolo, in which fish and meat may be dressed: he is of opinion that they take their heat from subterranean fires. Those waters that receive their heat from minerals, never acquire so high a degree of effervescence; nor are they found so very hot, but in the vicinity of places where the active fires appear. How great indeed is the difference in the heat of these two sorts of effervescent matter!

There are waters that issue from their springs warm, smoking, and bubbling: such, for example, are the waters of Bath. But we must not suffer our ourselves to be deceived by them: those waters, whatever their appearance be, are not as hot as common boiling water; Fahren-

heit's thermometer plunged in them would not rise to 212° . In the King's bath, at Bath, it rises at the time of the greatest heat, for this varies in the course of the year, no higher than 119° . The bubbling only indicates the expansion of an abundant quantity of gas, and does not even require a sensible warmth, for it takes place in cool liquids.

§ 42. We read in several works on Natural History, that water taken from a hot spring, the heat of which is owing to minerals only, and set immediately with all its own heat on a common fire, would not boil sooner than the ordinary cold water. This circumstance, were it real, would be decisive, and would prove a very easy means of ascertaining the true origin of the heat of all the springs.

It is strange that an error, for it is an error, so easy to be corrected should be so spread, and that it should be found in many writings which are in other respects very valuable. The water from a hot spring will boil sooner than cold water from a common spring; and to estimate it according to an experiment which

Mrs. Elizabeth Douglas, a lady of great information and judgment, had the goodness at my request to make on the Bath waters, it appears that the degree of heat in the water, when taken from the hot spring, is nearly so much gained towards completing the heat that remains to be acquired by the fire, to raise it to the degree of boiling water.

An equal quantity of the water of the King's bath, which is scarcely ever above 112 degrees, and common cold water being put into similar vessels on the same fire, the latter took double the time that the former did to boil : so that to make the two sorts of water begin to boil at the same time, it should seem that the water of the hot spring should not be put to the fire until the common cold water has acquired a degree of heat equal to the natural heat of the water of the hot spring.

I shall here add two observations, for which I am also indebted to Mrs. Douglas : the first is, that the Bath water left to grow cold, will afterwards take as long a time to begin to boil as common cold water ; nor do the mineral particles

with which, though cold, it remains impregnated quicken its ebullition. It is probably owing to a misunderstanding of this experiment, that what may be said of the waters of hot springs, when left to be cold, is asserted of them in their natural state.

The second observation is, that a mineral water retains its heat longer than common water heated to the same degree. A moment's reflexion suffices to convince us, that it is not so easy for the fiery particles to disengage themselves from water, which confines them in the mineral corpuscles with which it is charged, as to escape from a pure simple water.

CHAP. XII.

Volcanoes are not vents for a grand reservoir of fire in the centre of the globe. The astonishing quantity of the fires of Kamtchatka.

§ 43. **W**HEN I remark that the two countries of the Old World, where the volcanic fires most abound at present, have their meridians almost exactly opposite to each other, it is merely to determine, by a simple allusion, the position of the island of which we have been speaking, Iceland, relatively to that occupied on the globe by the peninsula of Kamtchatka, which we are going to consider under the same point of view, namely, the great quantity of its fires. Reckoning from the meridian of the island of Ferro, the westernmost of the Canaries, as most of the nations of Europe still do, we shall find these two regions situated at the two extremes of the eastern hemisphere; so that the first

meridian passing through Iceland, and Kamtchatka ending at the 180th degree, the Eastern Kamtchadales are what we call perioeci to the inhabitants on the West of Iceland, with a little difference as to the latitude. I would not have it supposed that I attach any other importance to this remark; for, I am very far from being of the opinion of some naturalists, respecting the existence of a fire in the centre of the globe, to which our volcanoes are merely vents. However awful their present effects, I think, that according to such an hypothesis, they would often prove much more calamitous. The displacing of seas, the overturning of vast regions of the earth, and general shocks throughout the globe, which have never been heard of, would necessarily and frequently be the consequences of the agitations and eruptions of a reservoir, which, in so dangerous a position, should from the immensity of its body extend its communications to a multitude of mouths dispersed throughout the earth. I consider volcanoes and internal fires only as accidents which affect the outer coats, if I may so express myself, of our globe; and I

should fear to exaggerate, were I to suppose, that the deepest of their abysses reached lower than the twenty-fourth part of the radius of the earth, that is, about a hundred and fifty miles : because that depth, by means of the horizontal divisions formed by the meeting of a number of natural passages, may suffice to explain the most extraordinary convulsive motions, which we learn from history, that the earth has suffered.

§ 44. The peninsula of Kamtchatka takes its name from a great river, the mouth of which divides it into North and South. It is situated at the Eastern extremity of the Old Continent, nearly in the same latitude as the Queen of Islands, Great Britain. Kamtchatka extends from the 51st to the 60th degree of latitude, which is its length : its mean breadth is only about three degrees, and its surface hardly equal to that of England and Wales. On the southern part of this narrow spot, however, there are no less than five immense volcanoes, which bear the following names : Awatcha, Joupanouskaïa, and Chevelitche,—which three are said to correspond, and to have simultaneous motions more or less

marked, — Tolbatchia, and Kamtchatkaia. The last, like mount Krasie in Iceland, ejects a great quantity of vitrified substances, which are found in the neighbourhood of it. How striking must have been this mountain, which can be seen at the distance of a hundred leagues, as we observed before, § 32, in the month of September 1787, when torrents of burning matter pouring from its crater, and flowing down on every side of its descent, presented to the sight the whole body of the mountain red hot ! Besides these volcanoes, there are many others, mentioned by authors whom we shall presently cite, which are but vaguely described, and are to the North of the river. Count Beniousky says, that the whole number in the peninsula amounts to twenty.

Here almost all the springs, and the waters of several lakes, are hot : and it is consequently observed that, notwithstanding the extreme rigour of the climate, none of the lakes, rivers, or rivulets are ever entirely frozen over : large openings where the water remains unaffected by the cold are always to be seen. This is a farther

indication of internal fires being either very extensive, or very numerous.

I have taken these details principally from a work very well known, and which deserves to be so: Travels in Siberia and Kamtchatka, by M. Kracheninnikow, Professor of the Academy of St. Petersburg, vol. iii. part 3. ch. 3. This author travelled all over the South of the peninsula. I say *principally*, because they are also to be found in Busching's accurate System of Geography; in the Memoirs, chap. 15, of Count Beniousky, who had the misfortune to be banished thither; in that excellent work, the view of the Russian Empire, by Mr. Tooke, vol. i.; and in other authors.

If we are to add to Kamtchatka the chain of the Kuruli Islands, which, all lying close together, seem to have been formerly a continuation of the peninsula, we shall find a volcano in each of the two first, Alaid and Poromousir, which are separated from it by a strait not more than seven or eight leagues wide. M. Kracheninnikow mentions them in the chapter above referred to, in alluding to an event, of

which we shall speak hereafter. We shall besides find seven other volcanoes, in seven of those islands, nearly following, noticed by Mr. Tooke, viz. Ikarma, Tchirikoutan, Rakkok, Etopow, Montoya, Tschirpo-oi, and another, which he does not name, in an island very near the last.

I do not mention the quantity of hot springs to be met with in those islands. It will naturally be presumed they are as numerous as on the peninsula. I cannot, however, but take notice, that there is one at Ussassyr, also mentioned by Mr. Tooke, which, by its prodigious spring into the air, brings to mind that of the New Giezer in Iceland.

Here then we have one or two and twenty volcanoes burning, to which is to be added a greater number, which, according to the authors referred to, are extinguished on a line of about two hundred and twenty leagues in length, and that almost a right line from North to South, for the difference in longitude of the position of all these volcanoes is not more than four degrees, from the 172d to the 176th.

A state of nature so extraordinary is in itself

interesting; and that an exact counterpart should exist in countries so distant from each other, as Kamtchatka and Iceland are, is worthy of remark: I therefore hope that a description of their situation, under this point of view, will not be thought misplaced, in a work appropriated to the explanation of that kind of phænomena, by which they are so particularly distinguished.

Not to dwell too long on this head, I shall refer the reader to § 52, for a detail of the effects occasioned by one of the last eruptions of one of these volcanoes. It will show their violence, and prove that they do not yield in fury either to Vesuvius or Etna.

CHAP. XIII.

Volcanoes render the places around them fertile and healthy. The danger of their vicinity.

§ 45. **THE** continued convulsions of several volcanoes, both on the Continent and in great islands, will allow of no settlements to be made within four or five leagues of them : but that is not the case with the greater number. Most of them have considerable intervals of repose. The ear then becomes accustomed to the groanings of the earth, and to the hollow rumbling of subterraneous thunder. The eye grows familiar with those whirling clouds of smoke and sparks that are perpetually flying up. Men by use live upon the resounding soil, although they know that it covers tremendous fires; and an inhabitant becomes, at length, less affected by the reality of his danger than we are by the idea we form of it. He thinks only of the prodigi-

ous fertility which those mountains scatter round them by their exhalations and sulphureous ashes, The additional salubrity which the air certainly derives from them, seems too a natural compensation for the apprehensions they may excite: to these allurements he yields, and we see man, always blindly rash where his interest or his pleasure is concerned, building villages and towns on those quaking vaults, the bases of which a fire is perpetually consuming. The largest city in Italy is at the foot of mount Vesuvius. Several great villages, and considerable towns, are situated on the declivities of Etna. The part beyond comparison most peopled of the vast Empire of Peru, is that which is the most exposed to similar danger; namely, the plain of Quito, which is fertilized by a number of lofty blazing summits.

§ 46. In this situation, however, not an hour but may become the last to a whole nation: for a volcano is doubly deceitful; it is so both during its sleep, and when it awakes. Nothing is more uncertain than the duration of its repose. It is sometimes ten years, sometimes

twenty, and more, without giving any alarm, Horrebow says, that mount Hecla was quiet from the year 1389 until 1558, when it broke out with all its fury. According to Dominic Galliano, a Sicilian author who has written a history of the known eruptions of Etna, the heads of which are in Mr. Houel's *Picturesque Travels*, vol. ii. page 117, &c. that volcano, after reposing nearly a century, from 1447 till 1536, during which period people had gone into its crater, and the inflammable matter was supposed to be exhausted, broke out again, on the 25th of April, with a tremendous noise; and torrents of sulphur and bitumen ran down its sides. On that day it was that Francis Negro de Piazza, a celebrated physician of Lentini, the ancient Leontium, going too near to the top, was killed and burnt by the fall of hot flints. On the 17th of April in the year following, 1537, there was an eruption of the same mountain still more tremendous; and its ravages extended throughout the whole island. A much more remarkable intermission still took place in one of the Lipari islands, called Volcano. Its

crater remained open, and smoke and sparks rose through it; but since an eruption which happened in the year 144 of the vulgar æra, no mention has been made of any other till the year 1444, an interval of thirteen centuries complete. Its return was indeed dreadful. It has since had other eruptions: the last two were in 1775 and 1780. It is known, that a volcano has sometimes broken out twice in one year: also, that after a long calm its renewal has been accompanied only with noises, or slight motions of no consequence, while at other times its sudden convulsions have been attended with the most dreadful calamities. The solidity of buildings proves no security; on the contrary, the more massy they are the more certain and destructive is their fall. Messina might have escaped many horrid disasters if its inhabitants would have observed the wise ordinance of King Roger. That conqueror of Sicily having witnessed the effects of those destructive fires, had for that reason interdicted the imprudent magnificence affected in their buildings. If any thing in fact can escape the general disaster, it is the poor man's cot;

its slight timber-work, supporting no load, easily humours all motions: but then, it is in danger of being burnt or swallowed up, so that man can find no security in a situation thus replete with peril.

CHAP. XIV.

What are the causes of the convulsions of a volcano? How do those causes act? Their effects upon the mountain, upon the adjacent places, and often at a very great distance.

§ 47. **BUT** by what cause are the convulsions of a volcano produced? The Academy of Naples, and the most celebrated naturalists have only been able to assign two: the pouring of some pool of rain-water or some lost spring into the prime fiery reservoir of the volcano; or, by an introduction into the reservoir of some currents of sulphur or metal recently melted by the casual extension of the fire. These seem but feeble causes; but if we reflect that the reservoir is itself a great burning lake, composed of materials the most susceptible of effervescence, we shall be convinced that a cause that excites and

increases the action of its fire suffices to produce an eruption. Now, in the first place, this is to be done by water; from the necessary consequences of its irresistible expansion. A very small quantity of water thrown on the furnace of one of our mines, where the metal is in fusion, would cause a sudden explosion capable of blowing up all the buildings near it. The force of such an expansion, says Mr. Whitehurst, is twenty-eight times more violent than that produced by gunpowder : can we then wonder at the terrible effects proceeding from a considerable body of water running into the immense burning pit of a volcano ? In the second place ; a fresh effusion of sulphur, bitumen, or melted metals may bring on a similar fermentation. We may form an idea of it by the effects of oil thrown on fire, or by those occasioned by the mixture of various metals or minerals when they are in a liquid state, either at an equal or different degree of heat, but especially the latter. How weak all comparison must be with the subject before us, will be more easily felt than I can possibly express.

§ 48. The moment that water, or those melted substances, come in contact with the fiery matter, frightful detonations follow in the interior of the abyss, which are repeated in all the cavities corresponding with it; at the same time the rarefaction of the air and vapours rapidly increases, and at intervals the mountain shakes, and the earth trembles. But if we suppose one of the causes we have mentioned, or both together, to take place in a sufficient degree, to rouse a general commotion in this ocean of fire which slumbered, what a tremendous conflict would there arise among the different elements of which it is composed? We see the unctuous substances we make use of ferment, and swell up in an astonishing manner on being boiled over our common fires: how then must that horrible fiery paste, rising as it boils, and boiling throughout its whole mass, ferment in its commotion! Neither the immense basin of the volcano, nor its deep windings, will long contain it; the sides of the mountain will be also attacked and agitated.

§ 49. Still, above the liquefied and boiling

substances, the air contained in the bosom of the mountain, and the thick vapours which are continually forming, become heated and rarefied to the highest degree: water when expanded into vapour forms a body thirteen or fourteen thousand times larger than when it is in its natural state. These two elements then demand infinitely more space; and they demand it with a violence proportioned, first, to the intenseness of the fire which expands them, an intenseness so great that substances of the most resisting nature and the least liable to be subdued by fire, yield to the volcanic conflagrations; and secondly, to the compression they afterwards undergo from the constant rising of the liquefied substances, either when the mountain has never been opened as in a first eruption, or when the crater has only been closed and obstructed, as we have already described in §§ 6 and 9. Being too closely shut up, they strive every where to disengage themselves: they agitate and shake the whole mountain, which seems on the point of being torn from its foundations, or flying into a thousand pieces. Its tremendous

working is accompanied with hollow roarings, to which nothing in the nature of sounds can be compared.

§ 50. The earth partakes of these terrible commotions to a great distance. The shocks of mount Etna are felt throughout Sicily, and those of Hecla throughout Iceland. The convulsions of Vesuvius are sometimes felt in a diameter of more than a hundred leagues. It frequently happens from these repeated oscillations of the earth, that the rarefied air, and the fire itself, spread and enter into conduits formed by nature, or deep caverns. If the ground is solid, it bursts open and leaves a frightful, bottomless, chasm; if it is cavernous, parts of the land to a considerable extent are swallowed up, and their place is commonly occupied by infectious, sulphureous, waters. Hills have been seen sinking into an abyss, from the vaults which supported them giving way. At other times, the force and abundance of the flames have thrown out small hills from the bowels of the earth: I have seen some of these eighty feet high. Mount *di Cineri*, or *Monte Nuovo*, not far from Puzzuoli, which

was produced in that manner in the night of Sept. 30th, 1538, is immense; it is a hundred and fifty feet high, and covers a league in circumference. They are of course solid bodies entirely burnt; and rise out of the earth in places where the ground has no acclivities. The successive efforts of the fires by which they were driven up are often perceived: in those cases they are distinguished by so many arches, which are concentric, rising one above the other, but always solid. *Monte Nuovo* is not in this state, because it was produced by a single instantaneous effort.

In so dreadful a crisis of nature what are cities? Catania, built over the vaults of Etna, has always been a considerable place, and, though much reduced, still contains more than thirty thousand souls. It has been observed, that in the course of two thousand years, there are few centuries in which it has not been entirely thrown down, and all its inhabitants, or at least the greater part of them, destroyed. Messina, seated at the foot of the same volcano, was much larger than Catania: but in

1783 its houses, palaces, walls, quays, citadel, were all overturned in the twinkling of an eye ; and it became a shapeless mass of ruins, where death was seen every where in different forms.

Forty years ago Jedo, the residence of Cubo, the civil and military Emperor of Japan, buried under its ruins, in an instant, two hundred thousand of its inhabitants : the town contains near two millions. The natural state of the great island of Nippon, where that capital is situated, is very similar to that of Iceland, from the number of its volcanoes, its internal fires, the quantity of sulphur, and its numerous hot-springs.

St. Jago, the capital of the province of Guatimala, in New Spain, was situated at the foot of a volcano, as high and as formidable as Etna. It was swallowed up in 1541 ; but afterwards rebuilt near three leagues distant from its first scite. It had become, from its population and wealth, the third city of Spanish America, when in the month of April 1773, it was completely destroyed : sixty thousand per-

sons of all colours perished in it, and in the neighbourhood. The loss in gold, silver, and merchandise, has been estimated at fifteen millions sterling.

The rich, populous valley of Quito, in Peru, eighty leagues in length by fifteen in breadth, was destroyed in a horrible manner in February 1797, by the eruptions of its volcanoes: new ones opening, and those that were apparently extinguished breaking out again. Nature seemed to be returning to its original chaos. Near fifty thousand persons perished, crushed by the fall of buildings and the mountains tumbling down, or swallowed up in the gulphs which opened, or drowned by the waters issuing from the earth; or, in short, burnt by the flames that rose out in other places. A burning lake of bitumen was formed near Rio-bamba. However great these disasters, they did not exceed those of Chili in 1646, though they brought to mind the description of them.

By the last accounts from Mexico, we are informed, that the magnificent port of Aca-

pulco, which was the emporium of the two Indies, was swallowed up on the 17th of June 1799. The particulars have not yet reached us.

CHAP. XV.

The sea, when near, partakes the motions of the earth. Prodigious oscillation of the sea at Awatcha. Illusion experienced by the people of Naples in 1779. The eruption of a volcano puts an end to the great conflict of nature.

§ 51. **BUT** the commotion is more alarming and more terrible if the volcano be situated, as most of them are, near the sea. Violently driven from the shore by the shocks of the earth, it leaves it, and seems to fly as if affrighted. The waves retire and accumulate at a distance to a great height, but are soon brought forward again by the necessity of a level: falling from the elevation to which they were forced to rise, and being also impelled by the re-action of the whole mass, they return, roaring and raging, to resume their former beds, and in that irresistible effort, pushing far beyond their accustomed limits,

they inundate the country to a great distance, drowning all that has the breath of life. Durazzo, the ancient Dyrachium, in Albania, though still a considerable place, was much larger about five centuries ago. It was totally ruined in 1269 by a volcano, which stands between it and Apollonia. In the midst of frightful subterraneous noises, the buildings throughout were overturned by very violent convulsions of the earth. This great town was suddenly buried with all its inhabitants, whom the calamity surprized in their sleep. The sea left its bed several times, and washed its very ruins. (*Le Beau; Histoire du Bas Empire, tome 22, page 324.*)

In 1746 both the earth and the sea from its bottom were so powerfully convulsed, by the fires unhappily collected under the ground near Lima, the capital of Peru, that ships were carried from Callao, the port of the town, to the distance of two leagues up the country, and buried in sand. In later times, during the earthquake at Lisbon, the ocean, in a similar oscillation, broke over the isthmus which unites

Cadiz to the Continent, and drowned several persons, among whom was the young Racine, who, it was said, promised to excel his father, and to attain a reputation equal to his grandfather's.

§ 52. Mr. Kracheninnikow in the same chapter of the work which we have cited, § 44, reports an event of this kind, suited to give an idea of the prodigious effects of these convulsions of the earth on that part of the sea with which it corresponds. This author landed in the bay of Awatcha, on the 14th of October 1737, eight days after the event he describes. The earth was still greatly agitated, and it continued in motion till the spring of the following year.

Mount Awatcha is situated on the North-side of the bay of the same name, in latitude $52^{\circ} 25'$, longitude 175° . On the 6th of October a violent eruption took place. The author observes, that, among other appearances, there issued clouds of ashes from the volcanoes in such great abundance, that the environs were all covered with them the depth of a *verchock*,

twenty lines, as was also the whole extent of the country over which the wind blew, to the distance of more than three hundred *verstes*, about two hundred and twenty-five miles. But I shall confine myself to the subject at present before us, that of the influence of the convulsions of the earth on the adjacent seas.

After the first concussion of the earth, the sea rose, and in the general agitation of its waves, it added its frightful roarings to the continual rumbling and repeated claps of subterranean thunder. It overflowed its usual limits, and rose to the height of about three *sagenes*, one and twenty English feet; but it soon again retreated to a considerable distance. A second concussion of the land took place, and the sea poured in upon it as violently as before, but in its retreat it retired so far as not to be seen. On this occasion chains of rocks, never before noticed, were observed at the bottom of the strait which is between Alaid and Poromousir, the first and second of the Kuruli islands, lying nearest the point of Kamtchatka. In the course of a quarter of an hour, dreadful concussions,

much more violent than the former, were felt. The sea then towered thirty *sagènes*, or two hundred and ten feet high ; and breaking over the land ran up a vast way. It remained there however but a short time ; the waves continuing long unsettled, retiring and advancing by turns : their height decreased at each alternation, the sea gradually abating, till at last it fell to its original level.

§ 53. Truly frightful, though of a different kind, was the phenomenon presented to the sight, by the extensive bay of Naples during the eruption of 1779. It happened in the night. Immense volumes of flames ascending with a spiral motion, set the air on fire to a very great height : the light, however, which they spread over all the horizon was received through a thick smoke of sulphur, and clouds of falling ashes. This gloomy light, reflected by the convulsed waves in the bay, completely imposed upon the imagination of the people of Naples, previously confused by the general disorder of nature. The bay had the appearance of a real sea of fire. It was believed for some

moments that the infernal abyss, which in fact lies under that place, had opened; that the water had sunk, and the bay filled with the fires, which the people thought they saw ready to destroy the quaking spot upon which Naples stood. Is it wonderful that persons of a weak constitution, and whose imaginations are susceptible and pliant, should be overcome by the attacks of such terrors ?

§ 54. We are not to suppose that this crisis of nature is instantaneous; it commonly continues in all its force with some intermissions for several days, sometimes for several months, which depends on the extent of the fiery reservoir, the quantity of burning matter, and the degree of facility afforded to the vapours and rarefied air to disengage themselves. In 1537, from the first to the twelfth of May, so great was the conflagration in the abysses of Etna, according to Fazello and Borellé, who wrote the history of that volcano; the rolling of the internal thunders was so frightful and continued, the convulsions of the earth were so strong and general, that it was feared the whole island

would fly to pieces and sink into the sea. The mount, notwithstanding, never ceased vomiting flames and lava ; but its immense mouth was not sufficient to throw out the fire. The island is of a triangular form, of fifty leagues for its base, thirty for its perpendicular, and its surface contains seven hundred and fifty ; had it not been for a multitude of wide and very deep chasms which gave passages to the fire, it would not perhaps have continued in existence.

CHAP. XVI.

The eruption of a volcano one of the grandest sights a man can behold. An idea of it. What causes it? The overspreading of the burning matter at the top of the column. Its whole form. The fall of the ejected substances. The prodigious distance to which they are sometimes carried.

§ 55. **T**HE eruption of the volcano, and the flowing of lava, generally restore a calm. A new scene then opens, which has its dangers, and brings with it new calamities, but these are neither so extensive nor so sudden as the former. It seldom happens but that the individuals whom they threaten have time to save themselves. Were we not absorbed by the sensation of destruction and terror which precede, we should say that the eye of man cannot enjoy a grander, more brilliant, or more awful sight, than that presented by a volcano at its eruption.

§ 56. Let the reader figure to himself Vesuvius near four thousand feet high, Etna which is more than twelve thousand, Pichinca which is fifteen thousand, Cotopaxis or Antisana, which are eighteen thousand ; or, in fine, the insular volcano we have already mentioned, which was thought to exceed Chinborago, and which, were it only equal to it, would still be nineteen thousand three hundred and ninety-two feet in height : let him imagine a column of fire of three or four miles in circumference, and sometimes more, whose height is more than double that of the mountain, rising from it with a thundering noise, greater than that of all the cannon in the world discharged together. It seems as if it would set the sky on fire : lightnings flash from it. The dazzling brightness of its fire could not be endured by the eye, did not immense spiral clouds of smoke moderate its fierceness at intervals. These spread through the atmosphere, which they thicken : the whole horizon is covered with darkness ; and at length nothing is to be seen but the burning summit of the mountain, and the wonderful column of fire.

§ 57. Its height, bulk, and explosion, result from the confinement in which the air had been kept within the volcano. Rarefied to the highest degree, forced on by the increasing heat of the immense pit, and pressed more and more by the prodigious fermentation of the lava, the inflamed air, reduced to the size of the crater, at length escapes, spinning round and round. Breaking the top of the shaft, it bears it along in a thousand pieces, with soot, ashes, and pumice, with which the sides of the abyss within were loaded. In this horrible whirlwind it is even common to see huge pieces of calcined rock, torn from the bosom of the mountain, carried into the air.

§ 58. The display of this phenomenon, in its extent and duration, depends upon the degree of force in the circumstances we have just mentioned. When the parts first raised lose this force, and, being left to their own weight, would naturally sink, those that come next, being still themselves supported, repel and throw them off. At that juncture an overspreading of the fire takes place at the top of the column which adds to its beauty. I think it must have been from

this view of it that the younger Pliny drew his comparison between the production of that eruption of Vesuvius, by which his uncle was killed, and of which he was himself an eye-witness, and the cypress tree.

§ 59. In a short time the whole of the column turns into a horrible shower of red hot rocks, flints, and ashes. Monstrous burning masses are seen bounding and rolling down the side of the mountain. Wo be to those places, which lie in the direction of the wind prevailing at the time of this tremendous shower ! Pompeii, Herculaneum, and Stabiæ, three towns to the Southwest of Vesuvius, disappeared, about seventeen centuries ago, by a similar occurrence : and it was only in this century (the eighteenth) that they were discovered. A column, such as that we have been describing, broke over them, and the land about them : they were buried more than fifty feet under a mass of ashes and calcined flints, which was farther covered by a bed of lava several feet deep. If the wind be violent the ashes are carried to an incredible distance.

§ 60. Rome and Venice, the former of which is a hundred and fifty miles from Vesuvius, and the latter double that distance, have been several times incommoded by its ashes. In our times, June 1794, all the South-east of Italy was covered by them. A letter written by the Archbishop of Tarento, dated June 18, during the eruption, says, "We are covered with thick clouds of volcanic ashes." Some variation of the wind must have altered the first course of that light substance, as the archbishop in his letter presumed that they proceeded from Stromboli or Etna. Those clouds passed Tarento, which is more than two hundred and fifty miles from Vesuvius, went beyond Otranto, at the extremity of the province of Lecce, and were lost in the Mediterranean at the entrance of the Adriatic Sea, nearly four hundred miles distant from the point of their departure. This no doubt is prodigious: but that the tops of the houses at Constantinople, which is almost a thousand miles from Vesuvius, should have been covered four inches with its ashes, would have been difficult to believe, had not contemporary

authors, some of whom were at the time living in that city, reported the fact, and uniformly dated it on the cleventh of November 472, at noon, when the people were attending the games of the Circus. (*See l'Histoire du Bas Empire, tome 8, page 59*). We are less surprised then to read that the ashes of Etna, which is three times as high as Vesuvius, and a little nearer to Egypt, reached Alexandria: a town, the inhabitants of which have lately witnessed an event, that, though of a different kind, must have appeared to them quite as extraordinary. At the Eastern confines of Africa, on the first of August 1798, they saw thunderbolts dart from the North-west of Europe, break suddenly over their shores, and in the course of a few hours completely destroy a powerful navy that rode at anchor before the town. I need not add, that the thunderbolts I mean were those of Great-Britain, directed by Lord Nelson.

CHAP. XVII.

Of the dry fog in 1783. It did not proceed either from the convulsions in Calabria, or from those in Iceland. The opinion of the Abbé Bertholon of the cause of that phenomenon.

§ 61. **T**HE known fact, that the ashes from a volcano are wafted to very distant regions gave occasion for recurring to it, to account for the famous fog which affected almost the whole of Europe for two months, in the year 1783.

It appeared suddenly on the 18th of June, pervading mountains as well as plains, the sea as well as the land, continuing exactly in the same state whether the sky was cloudy or clear, in rainy or dry weather, and from whatever point the wind came. Although this fog filled the atmosphere, and was very perceptible to the eye, yet things the most susceptible of moisture were not in the least affected by it ; for which

reason it was called the *dry fog*. None of the productions of the earth were injured by it. The particulars of this truly surprising phenomenon are to be found in a variety of writings published at that time, but especially in one entitled, *Les Observations sur Le Brouillard de 1783, par M. L'Abbé Bertholon*, which was justly among those most attended to by well informed persons.

The fires in Iceland, and the convulsions in Calabria, were every where the chief subject of conversation, when this fog suddenly appeared on the 18th of June; and as it came on after those, many readily believed it to be an effect of them. It was looked upon only as a diffusion, not of the ashes of those widely separated volcanoes, the very mention of which would have been repugnant to common sense, for there were no signs of it, but of the vapours from those furnaces.

§ 62. Even this opinion cannot be supported. The volcanoes in the island of Iceland, and those in Calabria had nothing to do with that alteration in the atmosphere.

In places where the volcanic exhalations are

most abundant, and where it is natural too to suppose that they are more closely blended with the air ; for example in Campania, now *Lavora*, and in Sicily, the usual serenity of the air is become proverbial ; the sun is no where more radiant ; and in these particulars the climate of Calabria is nowise inferior to those two countries. This is an incontestable proof, that, in the ordinary state of those fires, during the repose of the volcanoes, all the parts of their exhalations dense enough to obscure the air, are heavier than the air, that they can easily disengage themselves, and that they fall to the ground.

I agree that at the time of an explosion there is a very essential alteration in the atmosphere ; it is more loaded, more impregnated with vapours and a variety of heterogeneous particles ; and this both in a greater circumference and to a greater height. But, in the first place, either the air is calm, and in that case the necessary result of the eruption will not be very different from that of the usual state of the mountain—I mean to say, that after the quick fall of the more solid substances on the sides and environs of the

volcano, such of the vapours as could thicken the atmosphere would very soon follow ; they would come down at a very little distance from the crater, and the air would not be long in recovering every where its serenity. In fact this has always taken place under such circumstances :—

Or, in the second place, there is a current of air which, without being violent, is sufficient to give a direction to the exploded matter. All, then, that is not in that direction remains about the point of explosion ; while the parts caught by the current, and over which it has power, fall successively in the course it takes, coming to the ground sooner or later, nearer to, or farther from, the volcano, according to their specific gravity : but as we suppose the wind light, their gravitation being but weakly impeded, it will not be long before the atmosphere is freed from them, and consequently restored to its usual pureness, as in the foregoing cases :—

Or, in the third place, the ejected matter is carried off by a violent wind : if it continue in a direct line, the greater force and duration you

suppose it to have, the less will be the dispersion of the ashes and vapours ; they will be carried to a greater distance, but will be less widely spread. If on their way, before all the particles are fallen, the wind change, the new current, more powerful, lays hold of what remains, which it finally deposits:—

Or, in the fourth place, to leave none of the hypotheses which ascribe the origin of that fog to volcanic vapours unanswered, there remains the supposition of a violent whirlwind prevailing over the whole face of Europe, which disseminated those vapours, and caused a general darkness. But, 1st, this supposition is merely for argument ; for there was no such whirlwind at that period : the air, on the contrary, was almost every where calm at the time the fog came on, and while it lasted. 2dly, If a whirlwind of such a vast extent be possible, it never was before heard of ; and therefore it is not to be expected that it should be admitted as a fact without being proved. 3dly, The action and progression of the wind are known. However speedy a vehicle it be, its motion is successive.

Mr. Derham, a learned English naturalist, has proved by known ingenious experiments, that the wind, at its usual moderate rate, and in a direct course, travels fifteen miles an hour, and that rather more than forty-two is its greatest velocity. Now, though it is clear, that in the hypothesis advanced of the progressive expansion of a wind moving circularly, there would be much to be taken from this velocity, yet allowing it to be equal, it would still remain evident, that if the fog of 1783 had arisen in that manner from the volcanic vapours of Iceland, and those of Calabria, its progression might have been calculated; it would have appeared sooner at places near the points whence the vapours were wafted, and not all at once on the same day over the whole of Europe. This observation is strengthened by another, which is, that the convulsions of Calabria, which began on the 5th of February 1783, had almost ceased in the end of March, of course nearly three months before the appearance of the dry fog.

§ 63. In order to explain the rapidity with which this phenomenon came on, the Abbé

Bertholon, in the work we have alluded to, calls in the aid of means certainly the most plausible, that of the action of electricity. The propagation of it is in fact instantaneous. The Abbé says, that the great quantity of the electric fluid which occasioned the earthquakes in Iceland and Calabria was also the cause of the fog.

An opinion which obviates the greatest difficulty attending that phenomenon, namely, its sudden appearance, presents itself, it must be owned, with great weight : but when we go on to inquire how the electric action could fix a darkness in the air, we meet great difficulties again. We cannot be told that it is owing to the presence of the electric fire itself, for it is of all fires the liveliest, it is the pure element : and if it be said, that in consequence of the commotion given to the earth by the escape of the electric matter, there suddenly rose from the ground an infinite multitude of particles, which cast a dimness on the day-light, and uniformly darkened the atmosphere for nearly two months; it may be answered, among other things, 1st.

That such an effect would be quite new ; that the elementary fire always disengages itself with simplicity, with a pure light, and unaccompanied by any dull matter. 2dly, That even allowing the supposition of so prodigious a quantity of vapours, it would be difficult to admit, that in the great variety of the soils, in spite of the different density of the mass of the Alps, for example, and that of the plains, on land or at sea, their emissions should have been made through mediums so different, in the same twinkling of the eye, if I may use the expression, and produce every where a similar effect.

Whatever weight this last explanation of that astonishing darkness may have, it seems certain that the first, that which ascribes it to the vapours of the volcanic and central fires, and which introduced this discussion, is contrary to all probability.

CHAP. XVIII.

Of the nature of the substances ejected at the time of an eruption. Of the lava. Of the cause of its overflow. The manner in which it is disgorged.

§ 64. **THE** substances ejected at the time of the explosion of a volcano are not the lava: but, as we have observed, they are the shattered pieces of the head of the shaft which choked up the crater; and stones of all sizes suddenly torn from the bowels of the mountain. At the eruption of Vesuvius in 1779, besides the stones of a common size, which were thrown to a distance of thirty miles, a vitrified mass was found which lengthwise was a hundred and eight feet round, and seventeen in thickness, and which fell a quarter of a mile from the crater. There are also loose particles, an infinite multitude of pumice, a kind of porus calcined stone, very

light, and bearing a great resemblance to the look of sponge. They are mixed with ashes and soot, some black, some grey, and some red. Of this nature are all the volcanic ejections; of this nature are those that filled Herculaneum, and from which the streets of it are easily cleared since the lava which afterwards flowed over them has been pierced.

§ 65. The lava is a very different thing. It is the part of that immense mass of matter kept in fusion for years, which is disgorged after an eruption. The accidental effervescence which takes place in the pit of the abyss causes it to rise. In its rising, if it find any opening in the side of the mountain, or weak place which it can force, it there discharges itself; if not, the matter continuing to boil up from the progressive effect of the heat, the volcano emits its lava through its crater. The lava flows over for several days, as long as the boiling up continues, and there is sufficient matter to reach the mouth.

§ 66. In this view it is a real river of fire at its source. The red hot lava issues in immense bub-

bles. It does not however become a rapid current even on the declivity of the mountain, but rolls heavily, being of a consistency, as we have already observed, very compact and adhesive. As it descends, the stream widens : it burns up every thing consumable by fire in its way. Its waves seem to be inexhaustible ; they reach the plain in millions upon millions, often presenting to view a breadth of a mile and a half, and oft-times more. Here the following waves with difficulty press and impel those before : they rise one above the other in piles. At a certain distance from the crater, when the air has made a sensible impression on the lava, it flows in a body from twelve to fifteen feet high, over which the stream is constantly collecting a new. It is a wall of solid fire, for to windward one may approach near enough to touch the matter with a pole and try its resistance, although to leeward it is not to be borne within thirty paces without danger of suffocation. One might suppose, that the top of these accumulated and moving bodies would concrete and become fixed, but it is not so : the dreadful heat they

contain keeps them in a state sufficiently liquid to occasion the gradual rolling off of the mass; for it is in that manner that a stream of lava continues to run; and form a prolongation of this amazing wall. Five weeks after the eruption of 1794 the center of the thickest part of the lava was red-hot. The progression of the matter thus continues as long as it is supplied from the crater, which does not cease disgorging, until, after an emission more or less copious, the effervescence in the remainder of the matter contained in the gulph begins to subside. Then it still appears for some time bubbling at the rim of the crater, and afterwards contracts and sinks insensibly, till at last the mountain is restored to its usual calm.

The running of the lava sometimes occasions singular accidents. Sir William Hamilton mentions a fact reported to him by the Canon Recupero, an ingenious ecclesiastic of Catania, who accompanied him in his visit to Mount Etna in June 1769, which shows the activity and force of those currents. In the eruption

of 1669, a little hill covered with vines was undermined by the lava, and transported half a mile from the place where it stood, without the vines being damaged.

CHAP. XIX.

The incredible quantity of lava that issues from a volcano. The immense void it must leave. The principal fiery pits of volcanoes must have horizontal branches.

§ 67. ONE reads the accounts of these wonders, and believes them exaggerated; one sees them, and the imagination is terrified. It is no uncommon thing for Vesuvius, though it is now one of the lowest and smallest volcanoes, and has been disgorging lava for many centuries, to discharge enough in a single eruption to cover a space of ground with lava two leagues in length, one broad, and more than a hundred feet deep: a quantity which would give a cube of at least three billions, seven hundred and fifty millions of feet. Nearly that quantity was produced by the eruption of 1737. This volcano has since had several eruptions.

The last, which happened in June 1794, was very violent. The greater part of the crater was either shattered to pieces or fell into the abyss. So large and extended was the column that issued from it, that Vesuvius seemed to be little more than a molehill under it. The ashes were carried to the South-west extremities of Italy. Many places on the sides of the mountain opened. The lava took a course towards the town of Torre del Greco which it encompassed, and filled in several places to the height of more than forty feet. It ran into the sea, forming a stream of near a mile broad; its advance into the sea was six hundred and twenty-six feet, and it formed a promontory of forty-six feet in height, and a hundred and twenty of mean breadth.

In 1660, Kircher, in his work called, *Mundus Subterraneus*, lib. 4. cap. 8, says, that the ejections of Mount Etna collected, would produce a mass twenty times as large as the original one of that volcano: and yet after that, Etna in its eruption of 1669, by which 17000 of the inhabitants of Catania, and in Sicily altogether more than 60,000 persons perished, covered

with its lava, according to Sir William Hamilton, who has been on the spot, a space of fourteen miles in length and six in breadth; consequently a surface of eighty-four square miles, or 2,100,000,000 square feet, allowing five thousand feet to the length of the mile: a quantity which, though prodigious so far, is yet to be multiplied by the number of feet in the height of this mass, for the sum of the contents as already given goes only to the thickness of a foot. Now to suppose it only a hundred, this first deposit would be 210,000,000,000 cubic feet. I say this *first deposit*; because, besides this, the lava of the same eruption made another in the sea, into which it rolled, and fixing at the bottom raised a promontory two thousand feet in length, and one thousand in breadth. Allowing it the same height as the rest, there will be a million of cubic feet to add to the preceding amount.

Etna has, notwithstanding, had several eruptions since 1669, and particularly during this century, (the eighteenth,) in 1727, 1732, 1735, 1747, and 1755. The last of these, according

to the Chevalier de Dolomieu, produced a stream twelve miles long, one and a half broad, and of a mean height of two hundred feet. I speak only of the commotions of this mountain for a hundred and fifty years past. Now it has been burning from time immemorial; beyond the period to which profane history ascends.

§ 68. These remarks justify Seneca in affirming, *letter 79*, that the mountain furnishes an issue to the fire, but not fuel: *in ipso monte, non alimentum habet, sed viam*. We must, however, understand the expression of the philosopher in the true sense, as I presume it to be, that is to say, that by the word mountain he means only the apparent mass of it: for who, as we have already observed, can presume to say where ends the expansion acquired by such mountains before they reach their real base?

Let us in imagination descend, for instance, into the vast womb of Etna; let us endeavour to form an idea of the dimensions of that almost immeasurable void which must have been the consequence of so many ejections; let us reflect, that whenever there is a new overflow at

the top, this enormous gulph must be first filled, and that the lava which we see disgorged from the crater in such prodigious quantity is only the superabundance of the liquefied matter, which the mountain is too full to contain: for, the moment the fermentation abates, the overflowing ceases, the matter remaining in the basin sinks, and the space again becomes void, until another eruption.

§ 69. These particulars escaped the consideration of Buffon, when he said, that the pits of fire under volcanoes were not at a great depth. On the contrary, it is only very extensive ramifications, and most of those lower than the visible base of the mountain, though higher than the pit, that can, by pouring torrents of melted matter into it, supply it, and for so many ages furnish those infernal ejections. The insensible loss suffered by the mountain in its height within, would not be nearly enough. It must necessarily, therefore, be supplied through the horizontal soil below the visible foot of the mountain.

Sir William Hamilton has successfully com-

bated Buffon's opinion, of the seat of the fire of volcanoes being towards the center or near the summit of the mountain, with two strong arguments. The first he draws from the great distance at which the earthquakes are felt when the subterraneous fire is in commotion : their immense extent demonstrates the depth at which the cause is seated, and the violence with which it explodes must necessarily destroy the top of the mountain very soon. The second argument he deduces from the quantity of matter that issues, whether as ejections at the explosion or as lava : the small superficies which, according to Buffon's hypothesis would be the whole that supplies it, would soon be exhausted and disappear, and besides it evidently could not suffice for the production of the immensity of the ejections.

CHAP. XX.

The crater of a volcano sometimes vomits boiling water. Whence does the water proceed? Of the water-volcano of St. Jago de Guatemala.

§ 70. SOMETIMES torrents of boiling-water have been seen running from the top of the mountain. I do not mean to dwell on those that are necessarily produced by the fall of a shower of burning stones, or the descent of the lava, on the sides of a mountain covered with accumulated snow. Of this sort there was one in the eruption of Mount Etna in 1755, that was a mile and a half in breadth, which did a great deal of damage; and had it flowed upon the town of Catania, all the inhabitants would have inevitably been boiled to death. This discharge of water is mentioned by Mr. Brydone in his Tour through Sicily.

These torrents frequently occur in the eruptions of Hecla and Cotopaxis. M. de la Condamine, who was near the latter volcano in 1742, was witness to a similar inundation, by which a plain of several leagues was almost in an instant laid under water. What an immense quantity of snow must have been melted ! According to the experiments of M. de la Hire, a cube of snow of twelve inches gives only an inch cube of water.

But torrents have been known to issue sometimes from the crater itself, and from the burning bowels of the volcano. In the seventeenth century, Vesuvius, at a time when there was no snow upon it, produced a very considerable one, by which five hundred persons were drowned.

§ 71. Some writers have accounted for the phenomena of this kind, by supposing the sea to make its way into the pit of the volcano. M. Valmont de Bomare, in his *Dictionnaire raisonné universel d'Histoire Naturelle*, a work above my praise, is of this opinion. Speaking of the eruption we have mentioned, he says—" During

“an eruption of Vesuvius the sea of Naples
“was emptied, and seemed to be absorbed by
“that volcano, which soon inundated the fields
“with salt water.” *Vol. 15th of the Lyons
great edition 1791: Article Volcano.* That the
sea should retire from the Bay of Naples is
nothing extraordinary after what we saw in
§ 52. It must take place every time that
the oscillation of the earth proceeds directly
from the mountain towards the bay, in which
case the shore necessarily drives the sea back.
But as its retreat was, in the eruption referred
to, accidentally followed by a copious discharge
of salt water, M. de Bomare justly expresses the
concurrence by saying, that the sea of Naples
seemed absorbed by the volcano. To have as-
serted it as a fact would have been absurd; and I
only make this observation, to prevent any one
from mistaking this temporary disappearance of
the sea for an absolute proof of its real absorp-
tion by the volcano. I see, indeed, but one
argument in favour of the opinion, that the
discharge of water from the crater of a volcano
proceeds from the sea; and that is, that the

water so disgorged has the briny taste of sea water. But this fact, of which I have no doubt, does not convince me. Sea-water after boiling with such violence, would be rendered so acrid and bitter as not to be known again: whereas I easily conceive, that fresh water poured into those frightful reservoirs where all salts, particularly armoniac, abound, must be thrown out strongly impregnated with them, and possessing the acrimony of sea-water.

But independently of these reflexions, it appears to me too bold to suppose, that such a communication can be established between the sea and the inside of a volcano on shore; for if the fissure made in the mountain is but slender and instantaneous, the quantity of water that could pass into those immense cavities would be soon dispersed by evaporation alone: there never could be enough to supply an immense body of steam, and to disgorge also destructive torrents through the crater. If, on the other hand, we admit a breach equal to the production of those effects, it seems to me that the extinguishment of the volcano must be the

consequence of it. There are, it is true, volcanoes under the sea that open and close; but the submarine volcanoes have this essential difference, that their fires have no passage except at the point where the water endeavours to penetrate. There the air on fire is compelled to resist it, and does in fact resist it, as we shall see in its proper place. On the contrary, in a volcano on land, this air having a free passage, it must, when violently compressed, driven by the mass of sea-water which is supposed to rush in very abundantly, and repelled by the sides of the mountain, yield, and evidently be likely to extinguish the volcano.

I therefore consider the extraordinary circumstance of the discharge of water through the crater, either as a simple disgorging of the rain-water collected in cavities within the volcano, as Sir William Hamilton thinks; or as a consequence of the numberless concussions which occur in the bowels of the earth, at the time of the strong convulsions it suffers in those cases: distant reservoirs are opened, and

pour their waters into the pit of the volcano, which discharges them.

§ 72. In the range of the Cordilleras towards Mexico, there are two mountains near St. Jago de Guatemala remarkable for their prodigious size and height, and to which travellers in their narratives, following the example of the natives, give the name of volcanoes. They call one of them the *fire-volcano*: this is the same of which we have spoken in § 50, when we had occasion to mention the repeated destruction of the unfortunate city of St. Jago. It is a little lower than the other, which they call the *water-volcano*, from the astonishing number of streams that descend from it. We are told by some writers, who were misinformed, or who were perhaps fond of the marvellous, that these are only one mountain with two peaks on the same base. If that were really the case, it would be very difficult to account for the circumstances above mentioned: but it is no such thing. Rogers, who has been upon the spot, expressly says, that they are two distinct moun-

tains, three leagues distant from each other. The only observation, therefore, that remains to be made here, is respecting the peculiarity of the denomination of *water-volcano*, which must have arisen from the ignorance of the people of Guatemala as to the just acceptation of the word volcano; it is probable, that hearing the mountain whence issued dreadful fires called by that name, they equally applied it to that whence a multitude of rivulets flowed.

CHAP. XXI.

Nature proceeds uniformly in the discharge from volcanoes. Wherever the lava flows, it creates a sterility of an indefinite duration. Quarries opened in the lava. The variety of colours in the lava. Vitrified masses most common near certain volcanoes.

§ 73. **O**UR only reason for particularizing Vesuvius and Etna, on the subject of the overflow of the lava, is, that being nearer to us, and more frequented by the learned of Europe, our information respecting them is more detailed and certain; but it is to be understood, that, as Nature proceeds uniformly in her works of the same kind, whatever we have hitherto said of these is applicable to all. The volcano in the Isle of Bourbon, and that in the island of Ascension, have covered and burnt the country for more than a distance of two leagues

from their summits. The Peak of Teneriffe has overflowed all its environs a great way with its lava. Mount Gounapi in the island of Banda, and the mountain near the city of Panarucan in the north-east of the island of Java, have produced prodigious quantities of lava: so have the volcanoes of Arequipa, Cotopaxis, and Pichinca in Peru. Popocatepeco in Mexico, into which the followers of Cortez were bold enough to descend in order to get sulphur to make gunpowder, of which they were in want, has in like manner desolated the adjacent country. The soil for two leagues round the volcano of St. Peter d'Awatcha, and also that round Hecla, and other volcanoes in Iceland, is entirely burnt up. In a word, all burning mountains have the same effect in rendering the places on which they disgorge their lava lastingly barren.

§ 74. Care must be taken, however, to distinguish what we now advance, from what is asserted by travellers and writers upon natural history, that volcanoes contribute to the fertility of a country. No doubt they do, and

greatly, by the fall of all kinds of salts which their constant smoke spreads around, and of that of their ashes and soot during an eruption. We have ourselves already made this observation in § 45, but it must not be understood of those parts which are covered with lava. That covering is a solid mass of melted stone incompatible with vegetation. Although parts of Vesuvius are cultivated, and yield, among other wines, that valuable one known for its excellence under the irreverent name of *Lachrymæ Christi*, we are not to imagine that the vine is planted on the bare lava, for it would have been fruitless, but on the beds formed by the ashes, soot, and tufa, which have issued at the time of eruptions, and covered the lava in some places. A bed of lava admits no cultivation : it is a desert soil presenting a hideous appearance, and horribly rough. From the fierce burning of the stream, the after-waves keep those over which they flow, in a state of fusion : but as the last waves do not yield their tops to the heat and weight of new ones, they remain exactly in the state in which they flow ; only that, by a natural

effect of the settling of the matter in cooling, they are every where cracked to the depth of six, eight, and ten inches. Nothing, in my opinion, could give a better idea of such a plain, than an angry sea suddenly caught by a piercing frost, and frozen before the violence of its waves could subside. I have seen, I have walked over several of these plains of fatal lava, which the lapse of thirty centuries assuredly, and perhaps more, has not been able to render productive in the slightest degree. There is only some scattered broom to be seen in little bottoms, where the rain and wind have collected atmospheric subsidence.

I shall take this occasion to inform travellers who visit places where there are extinguished volcanoes, or where they are not extinguished, though not in eruption, that the best way of observing the manner of the flowing and progress of the lava, is not to remain inspecting and walking over the plain it forms, but to go off the bed of the lava and follow the edges of it, by which they will obtain very accurate ideas; they will ascend its current

laterally to the crater from which it descended, they will be highly gratified, and will see this phenomenon as it really was in its original state; heat and motion excepted.

§ 75. The industry of man turns every thing to advantage. Very profitable quarries are opened in these massy plains. The working of them requires great toil, for the substances have not distinct beds, unless an old discharge is covered by a new one, which is always easily known by the difference of the grain of the lava. The upper coats are extremely spongy and light: these are used for the construction of vaults and roofs, and also for the foundations of buildings. But the lava in the body of the quarry, and especially that at the bottom, is a fine stone of a beautiful grain, slightly porous, like bread that is well leavened and kneaded, and it is of course excellent for building. This difference is owing to the weight of the substances which enter into the composition of the lava. It is commonly a mixture of stones, marbles, iron, and copper. Now, the stone and the marble being three times as light as the iron, and the

copper an eighth heavier than the iron, when this amalgam, while yet fluid, is settling, the heavier parts will make their way in greater quantity to the bottom.

§ 76. The colour of the lava is generally a blackish grey. It is not uncommon to find some in which red predominates. I have seen one sort, but I never saw more than one, which was a mixture of yellow, bright grey, blue, and red; an exact *œil de perdrix*: it was a magnificent stone. A large mansion was built with it above four centuries ago, yet time has effected no change whatever upon it. It was taken from the lava of an ancient volcano in Auvergne, which still bears the expressive name of Tartaret: it is evident that this mountain has been dreadfully agitated by fire. There is a bed of lava of the same tints near Mount Somma, which it is well known makes a part of Vesuvius: this bed has been remarked and described by M. de Saussure. *See chap. 5. page 182.* A volcano does not always discharge lava of the same hue. The lava takes its colour from the different kinds of earth, from the minerals,

metals, and stones, which abound most at the time of its actual formation—That of Etna is little diversified, and is of a very dark grey. There is, on the contrary, a great variety in the lava of Vesuvius. There are slabs made of it, which are very curious and in great request : in these the yellow tinge is most apparent. The pieces dug out are cemented in a solid manner, and the whole takes a very fine polish.

§ 77. It is to be observed that all volcanoes at times throw out substances, in greater or smaller quantities, in which vitrification is very apparent: some are more remarkable than others for the abundance of this kind of ejected matter. Horrebow, in his History of Iceland, chap. 16, tells us that all the environs of Mount Krafle, on the North-east part of the island, are covered with lumps of glass. Here is found what is improperly called the black agate of Iceland, which, like the *galinace* of Peru, is nothing more than a blackish, opaque, glass, very hard and very heavy, annealed in those fierce laboratories of nature. Kracheninnikow also saw a great deal of glass about the volcano of Kamtchatkaia;

vol. iii. part 3. chap. 3. and expresses his surprise at the quantity of it. The naturalists who accompanied M. de la Peyrouse, made similar observations in several places ; particularly at the island of Assumption. They found the crater of the volcano there, which is always smoking, in a very singular state : it is entirely stuccoed with a soot-coloured glass.

This kind of ejected matter may proceed from the nature of the melted substances, and from the different salts which enter into its composition : but it may also be the effect of a longer and fiercer action of the fire upon it. I have seen the inside of the walls of a furnace, which was built of lava-stone, and was used for casting large bells, turned into this black glass, the substance having slakened and plastered the whole inside.

CHAP. -XXII.

Volcanoes become extinct, from the mines being exhausted; from the falling of the summit; from the rending of the sides of the mountain; from the sinking of the mountain itself into its own abyss; from the entire inundation of the reservoir of fire, and from its being dried up.

§ 78. **T**HAT the means by which a volcano is supported should in time be exhausted is not surprising: on the contrary, we are astonished that those means should have supplied it for so many centuries. But when we reflect on the variety of circumstances necessary to the formation and support of a volcano, we find that its extinguishment may be the effect of different causes.

We may recollect in the first place, that when we concurred with the greater number of

naturalists in laying it down as a fact, that several of the mountains which vomit fire contained their fiery reservoirs within themselves; we observed with respect to subterranean fires, that it was more than probable that they caused the conflagration of a number of other mountains whose situation was favourable to it, and that they supplied matter for their ejections; which seems to distinguish two classes of volcanoes on land.

§ 79. It is out of our reach to decide this difference, and say which volcano is sustained by its own fires, and which by borrowed ones. I think, however, that there are two circumstances by which we may be led to judge whether a volcano has a farther communication, or is fed by a distinct pit peculiar to the mountain. The first is, when its convulsions are observed to be simultaneous with those of another volcano. Such are several of those of Iceland; those of Etna and the Lipari islands; those of Awatcha, Joupanowskaïa, and Chevelitche, three of the five volcanoes of the southern part of the great peninsula of Kamtchatca; and such certainly are several of those of Peru. In fact, when a

volcano of one of these groups is in a fermentation, the others are observed to partake of it. In the last calamities of the province of Quito, several of its burning volcanoes were seen commencing their eruption at the same time, and some of the mountains between them broke out into volcanoes, either for the first time, or by a return of their extinguished fires. Volcanoes which communicate, do not for that reason all thunder with the same violence ; but their restlessness is always observed by changes and noises more or less perceptible. There is nothing extraordinary in these differences, which are necessarily the effect of the difference of the internal state of each of the tops of the group : besides, the greater distance from the general reservoir or inflammatory acting cause, the greater or less the elevation of the communicating conduits, and a number of other accidental circumstances, must prevent their being all equal in their operation.

§ 80. The second circumstance from which we may presume that a volcano, though standing alone, has a similar communication with a sub-

terranean fire beyond the mountain, is, when its ejections are very copious, very ancient, and very often repeated. Such certainly is Vesuvius, as may be supposed from what we have said of it, and more decisively still from what we have yet to say of the renovation of its fires. Such probably are some of those in the Moluccas, Japan, Marianas, and elsewhere, which are known to be more subject to violent and frequent eruptions; and whose great antiquity is proved, in default of memorials, by the immense emissions deposited on the lands adjacent to them. For the same reasons, I incline to think, that most of the existing volcanoes have a correspondence with subterranean fires, I mean such as are beyond the foundations of their mountains. This correspondence and particular position are no security against the extinction of volcanoes of this kind; because, in the first place, those subterranean fires are themselves liable to it; and in the second, allowing those fires to continue burning, it is very possible that internal accidents should by chance cut off the communication between

them and the mountain: being, in that case, reduced to its own means of support, it would be the sooner exhausted and become extinct. This has no doubt happened to several mountains in Asia Minor that were formerly burning: for, although we are unfortunately convinced that there is a great quantity of subterranean fire existing there still, we know only Mount Chimera that remains burning, as we have before observed.

§ 81. From the moment the correspondence with other subterranean fires is interrupted, the two classes we have been distinguishing are confounded; and it only remains for us now to inquire into the causes that operate the extinction of a single volcano, which has always drawn, or which has been reduced to draw its aliment solely from the interior of the mountain in which it exists.

A volcanic mountain of course contains mines and inflammable matter. We know that those substances renew themselves: but, it is also certain, that time or the effect of fire will entirely wear away the womb that contains them; and,

that the reproduction of them consequently must necessarily have an end, which end will also be that of the volcano. Ovid, in the 15th book of the *Metamorphoses*, mentioning various changes which had taken place on the globe, expresses with a brief simplicity that already suffered by a volcanic mountain, and that which awaits it. "Etna, says he, now so furious, was formerly a common mountain, nor will it always remain a burning one:

"Nec quæ sulfureis ardet fornacibus Ætna

"Ignea semper erit, neque enim fuit ignea semper."

He foresaw the end of its fires by the means we have stated, the decay of the inflammable matter:

"Nempe ubi terra cibos alimentaue pinguis flammæ

"Non dabit, absumptis per longum viribus ævum,

"Naturæque suum nutrimentum deerit edaci

"Non feret illa famem, desertaue deseret ignes."

There are, in fact, a great number of extinguished volcanoes, the mountains of which are not at all misshapen; their crater being simply stopped up. In walking over the heights

of the mountain, we find from a deep hollow sound, that the abyss still remains beneath our feet. It is only fuel that has been wanting to these volcanoes; in proof of which, I shall confine myself to a fact, related in the Memoirs of the Academy of Sciences. During the long earthquake which affected all the South of Italy, almost without intermission, from the month of October 1702, to the month of July 1703, a very old extinguished volcano near Sigillo, in Abruzzo-ultra, suddenly lost the covering of its crater: smoke and flames issued from it for three days, since which it has remained perfectly quiet. The mouth of the abyss is a diameter of twenty-two or twenty-three feet, but no bottom can be found to it, although it has been sounded with a line eighteen hundred feet in length. The convulsions of the earth, no doubt, opened a temporary communication between this abyss and a burning pit in its neighbourhood. But it is manifest that the mountain itself was exhausted, and had no more fuel to supply its fire; otherwise, agitated as it was, it must have rekindled.

Among the volcanoes which have been ex-

tinguished in this manner, there are several so entirely consumed within, as to be reduced to the mere crust, if I may so express myself, of the mountain: a state easily ascertained by the deep and hollow sounds reverberated by the whole surface. I have nowhere read that an attempt has ever been made to open, on the side, a passage into any of these curious abysses; which surprises me, as such an undertaking, the expenses of which would not be much felt by men of fortune in their travels, would probably be attended with important information on this part of natural history.

§ 82. The fall of the summit of the mountain, the loss of its crown, if I dare ~~use~~ use the expression, or a great rupture in its sides, would also be causes of extinction. As the absolute want of a circulation of air would prevent the expansion of the matter, which, by the means of a confined circulating air, would give birth to a volcano; so on the other hand, a circulation of air absolutely free would extinguish it. For, besides that it would be impossible for an explosion to take place in it, as the air, having full

liberty to dilate, would not be compressed, all the other causes of this grand phenomenon would soon fail; for the fierceness of the fire being throughout and incessantly kept up by the activity of the air, all the aliments which might otherwise have given a longer duration to the volcano, would in a short time be consumed. There was a volcanic mountain at Machian, one of the five small invaluable Molucca Isles, which, in the violence of its eruption, completely rent itself from the summit to the base; and horrible spiral clouds of smoke and flame issued from it. At present it forms two distinct mountains standing near each other. The event took place in the year 1646, since which there has been no eruption. A similar circumstance happened at Japan, where the side of Mount Fesi had widely burst open: the mountain from that time, discontinued vomiting fire, emitting only smoke. The uniform account given by all travellers of the present state of Mount Ararat, in Armenia, leads us to suppose, that the extinction of that old volcano was in consequence of the loss of its summit. The whole inside of

it is open. To a similar cause, it should seem, must be ascribed the extinction of the volcano seen at the southern extremity of Easter Island, in longitude 127° West, latitude 27° South; by the persons who accompanied M. de la Peyrouse; for there is a great breach in the summit of the mountain. The abyss indeed is now inundated; but it is highly probable that the destruction of the crater preceded the inundation. I have seen extinguished volcanoes, of which there remained only the props on which the vaults formerly rested. It is clearly impossible that a volcano, reduced to this state, should continue to exist.

§ 83. We have been treating only of ordinary losses, which becoming considerable in time, may cause the extinction of the volcano: but it has sometimes happened, that the whole visible upper part of the mountain has buried itself, and been lost in its own abyss. In this case, water always takes the place of the fire, and a volcano is succeeded by a lake.

This event is the consequence of the interior structure of the burning mount; as when, for

example, the beds of inflammable matter are raised, and approach too near to the level of the earth, and are besides very numerous or very copious. The time must come when, by consuming the visible base they will deprive the upper part of the support necessary to it. It no longer maintains its position, but from being on all sides held together by the firmness of the ground. A strong shock by its oscillations will cause all above the level of the plain to lose its perpendicular, the elevated mass will then fall in entirely, and choke the fire of the volcano with the immensity of its ruins. The waters over which it had so long risen, and which it had caused to evaporate by the intensity of the heat hitherto kept up, now rise in turn, and soon completely extinguish it.

Some lakes in the ecclesiastical state, particularly one of those near Viterbo, and that of Agnano, are said to have been formed in this manner. Their environs certainly bear the marks of fire, and denote an event of the nature abovementioned. In several countries similar traditions are current. These accounts may be

supported in places where they are corroborated by the appearance of lava, by the following fact which, in speaking of epochas in the history of nature, may be called recent.

The volcano of the Peak, in the island of Timor, one of the Moluccas, is known to have served as a prodigious watch-light, which was seen at sea at a distance of more than three hundred miles. In the year 1638 the mountain, in a violent eruption, entirely disappeared, and in its place there is now a lake. The remembrance of this surprising metamorphosis may be lost; but the volcanic emissions deposited round the lake are enough to disclose the secret to the remotest posterity. This is the case respecting ourselves, in regard to several lakes in similar circumstances.

§ 84. A fourth equally powerful cause by which an extinction may happen, is the introduction of a great body of water, or of a very copious stream, into the pit of the volcano. This supposes a vast reservoir situated at a greater or less distance from the volcanic pit, which is often the case in mountainous coun-

tries. The numerous convulsions of the earth must have assisted in opening conduits in the direction of such waters, which, on the fall, fissure, or melting of the obstructing matter that confines them, rush into the pit. According to the quantity of the body which flows in, results either the phenomenon of which we spoke in § 71, supposing the fire superior in force; or the choking of the volcano, if it be overpowered by the water. But while I show the possibility of the thing, I must add, that in general we have no certain means of determining, by the view of a volcano in this state, whether it was reduced in the manner we have pointed out, or whether the water has only flowed in, and inundated the pit after the fire has been extinguished by some other cause. In both cases the appearance would be the same.

A vast basin of water, of immense depth, placed on a mountain of which the surface and foot are loaded with volcanic emissions, and the whole rim of the basin horribly burnt, is a sight that in itself creates surprise. This undoubted union of the two adverse elements, the appear-

ance of water and the marks of fire, presents to the mind a kind of enigma, the solution of which must be sought in one of the two hypotheses given.

Near the town of Besse, in Auvergne, there is a mountain, which is at present overtopped by others. It was once burning: the foot of it is covered with lava; on its summit is a wide opening, and its vast bosom is entirely overflowed. The attempts to sound its depth have been fruitless. It is called indifferently the Gulph or Lake of St. Pavin. The inner accessible sides of this tunnel are burnt, and every thing demonstrates that the abyss of water was formerly an abyss of fire; but it does not seem possible to decide, at present, whether the water extinguished the volcano, or flowed in after it was extinguished.

I will mention another example of this kind which I find in the voyage of M. de La Peyrouse, *Vol. 2, p. 101*. Easter Island, *Lon. 97° W. Lat. 27° S.* is covered with lava. At the southern extremity of the island is the crater of an ancient volcano, the large-

ness, depth, and regularity of which raised the admiration of the French officers and naturalists. It is a cone broken short and turned upside down, for the upper rim is the widest: the circumference of it is two miles, and its depth at least eight hundred feet. They saw water in it, which was sweet. A great breach had been made in this crater by the ground tumbling into the sea. Here we perceive three possible causes of extinction, but I see no reason for adopting any one in preference.

There are cases, however, in which a decided opinion may be formed. Mr. Brydone in his *Tour through Sicily, Letter 11*, describes a lake which is precisely in the same circumstances as that of St. Pavin. It is situated on one of the risings on the West-side of Etna. This lake fills the whole cavity of the mount which it occupies. The crater of it is completely burnt, and no bottom has been found. It is undoubtedly, says Mr. Brydone, a volcano changed to a lake. Here I should be induced by the situation to think, that this volcano was not overflowed till after it was extinguished. It can be

considered only as a secondary mouth opened over the fires of Etna. It may have afterwards become a distinct mount; some accident may have obstructed the passages of communication; the fire have ceased burning, and rain-water, and perhaps some spring also may in time have filled the basin.

§ 85. Another cause which, though at first it appears paradoxical, is allowed by all naturalists, is the drying up of the waters in the neighbourhood of a volcano. It is acknowledged that they serve not only to rouse it into action at intervals, as we have shown; but by gently falling upon and moistening the substances which feed the volcano, they contribute also to its duration, because they prevent a too general and too sudden conflagration. We shall be convinced of the necessity of the adjacency of water for the support of a volcano, by considering that all that exist are, in fact, in islands, or not far from the sea, or near great lakes; or, lastly, that they are situated in high chains of mountains whence water flows in abundance, which denotes vast reservoirs. None are to be found actually burn-

ing but in one or other of these circumstances. This opinion is farther strengthened by observing, that if, in the multitude of volcanoes which were formerly burning but are now extinguished, some are found in the interior of countries, the situation of which seems to contradict our assertion by their distance from the great bodies of water; an accurate examination of the spot satisfies us that those places were formerly under water: whence naturally result the two following inferences: first, that their situation was not originally in opposition to the general law; and secondly, that the extinction of those volcanoes was owing to the draining off of the waters, either naturally or artificially.

CHAP. XXIII.

The earth has been desolated by a great number of volcanoes. The probable cause of the extinction of those in the islands of the Grecian Archipelago.

§ 86. IT is impossible to have read or travelled with any degree of attention, without knowing that there have been many volcanoes in existence which are extinguished. But when we dwell upon the detail, we are indeed surprised at the almost endless number of them that have agitated the globe in ancient times.

I believe that I am within bounds, in supposing, that there is now scarcely a fifth part actually burning on the earth of those that have existed : according to which the whole number of those extinguished would amount, as we shall presently see, to near nine hundred. To limit ourselves only to Europe, and even to those

parts of it which have been most frequented by naturalists, which is greatly contracting our first position, we find Sir William Hamilton, the best judge on this occasion, pointing out several of them on the course of the Rhine. His observation diminishes our surprise at the report made by Tacitus, in the 13th book of his Annals, of the fires which in the reign of Nero rose out of the earth in spiral masses, and laid waste a part of the Lower Palatinate, as far as the neighbourhood of Cologne. After Sir William Hamilton, Mr. Raspe, and Prince Gallitzin, have mentioned and described a number of mountains in the country of Fulda, in Hesse, and Thuringia, as having burnt in very remote times. In France, Auvergne, Velai, Vivarez, and the southern part of Languedoc were covered with volcanoes; and there were some in Provence. It is well known, that in Italy, from the Bolognese and Tuscany to the bottom of Calabria, there were every where indubitable vestiges of them; but very lately, Mr. George Graydon, an Irish gentleman, who possesses every estimable quality, and the Abbé

Fortis, one of the most distinguished writers of Italy, have taken the pains personally to ascertain, that more to the northward of the same quarter several of the mountains of the Veronese, of the Vicentin, and of the Paduan, have been burning ones. Dolomieu met with several extinguished volcanoes in Portugal. Almost all the mountains of Sicily have been in a similar state. The same may be said of the island of Elba, and of the northern part of the Bay of Naples. Most of the Eolian or Lipari islands still emit smoke. It has been thought that these and Sicily formerly joined, though only these tops at present remain, the other parts having been sunk ; as the vaults, which served as supports, had given way in consequence of the repeated shocks occasioned by the proximity of so many volcanoes. The island of Lemnos, in which the ancients placed one of the forges of Vulcan, and the greater number of the other islands of the Grecian Archipelago having been volcanoes, we might make the same conjectures respecting them : but this is positively contradicted by Diodorus Siculus,

on authorities which he drew from the remotest antiquity, authorities which all the observations of modern naturalists confirm. See *Tournefort's Relation d'un Voyage au Levant*, tome 1. p. 80, and tome 2. p. 63 ; *Mr. Pallas's Travels*, vol. v. page 190, French Edition. Diodorus says, that this great alteration in that part of the world which now divides Europe from Asia was wrought by the overflowing of the Euxine Sea, at one or two periods: an alteration which probably occasioned another ; namely, the extinction of that multitude of volcanoes, which almost all the peaks that tower in this Archipelago prove to have formerly existed.

§ 87. The influx of large rivers, such as the Danube and the Tanaïs, or Don, and of a great number of streams which run into the Euxine, having raised its waters, they opened a passage for themselves, which formed the Bosphorus of Thrace. It is difficult to determine whether at that important period the Euxine was no more than what it remains in our days, a great lake, having only a common passage for its discharge

by the Mediterranean into the Ocean; or, whether it was itself another real Mediterranean Sea communicating with the North Seas. For, besides that all antiquity attests its communication with the Ocean, a number of circumstances render it probable, especially the briny taste of its water: and, although bitumen, salt springs, and salt mines, are found in its neighbourhood, it appears hardly possible to maintain the opinion of the authors, who suppose the saline and bituminous taste of so prodigious a quantity of water to be thence acquired. Lake Baikal, though of considerable magnitude, has a much smaller extent of surface than the Euxine Sea. The learned Muller makes Lake Baikal five hundred and fifty *versts*, about a hundred and thirty leagues in length, and sixty *versts*, near fifteen leagues, of mean breadth; eighteen hundred and twenty square leagues: whereas the Euxine, two hundred and fifty-two leagues long, and one hundred broad, presents a surface of twenty-five thousand two hundred leagues; so that Lake Baikal is to the Euxine,

within a very little, as one to fourteen. Now, Mr. Pallas, *vol. iv. page 107, de ses Voyages*; and Muller, *Geographical Dictionary of Russia, at the word Baikal*, who have both sailed upon the lake, and travelled over its environs, declare alike, that although salt springs and salt mines are common near this lake, sources of bitumen to be met with, and farther still, which we should particularly notice, the lake itself casts it up in several places, the inhabitants of the borders collecting it to make lights, the water nevertheless remains sweet and fit to drink.

On this comparative view, can it be supposed that the water of the Euxine could have acquired its briny taste from causes which, though more abundant on Lake Baikal, produce no change in the water of that lake, the quantity of which is so much less?

This saltness then would alone be sufficient to prove, that the Euxine anciently made a part of the Ocean. It must have been formed by the successive flowing of the Frozen Sea into

the White Sea of Lapland; of the White Sea into the Baltic, and of the Baltic into the Euxine. For, the Baltic, discharging itself into the North Sea, would of itself have been no immediate channel of communication for the Euxine with the Ocean. The period of the formation of Baffin's Bay, and Hudson's Bay, or that of the Gulph of Mexico, may have been also the period of the interruption of the communication between the Baltic and the Euxine, which seems to have been long anterior to the interruption of that between the White Sea and the Baltic.

This grand communication probably still continued open at the time of the first change, mentioned by Diodorus Siculus, that which originally formed the vast Grecian Archipelago. It is, perhaps, to that fearful irruption of the Euxine we must attribute, as we have already said, the almost general extinction of that multitude of volcanoes which had been ^{as} ^{er-} ^{ning} on the eastern and southern shores of Asia Minor, and in several of the Greek islands. It may have been the effect of the

inundation produced by it in most of their abysses. To account for an effect of such magnitude, we must have recourse to an adequate cause.

CHAP. XXIV.

*The Giants' Causeway. Its wonderful formation.
Various opinions respecting its origin.*

§ 88. **I**T has been discussed, but never yet decided, whether there have been volcanoes in Ireland. There does not seem to be any other grounds for the affirmative than the existence of the Giants' Causeway. The common people, struck with the regularity of that immense object, judged it to be the work of men; and on account of the extraordinary strength it must have required, they supposed those men to have been giants. But why should we be astonished to find nature regular in great as well as in small objects? Consequently, in this causeway, as well as in the grains of the various salts, and in all the other smaller crystals? Allow this, and there is no farther occasion to have recourse, on

this subject, either to the skill of man, or to a race superior to the present species.

This famous causeway is in the county of Antrim. It is a collection of columns regularly disposed, each adapted to those that are round it, so as to leave no vacancy in the whole. It extends visibly without interruption about fourteen English miles, part on land and part in the sea, where the end of it is by no means ascertained, for it sinks by degrees the farther it is traced under the water.

The regularity is not confined to the composition of the general pile, but descends to the formation of each column. The substance is throughout of the same nature; and is a species of marble of an iron-grey colour, with which the ancients were acquainted under the name of Basaltes. This substance in its weight, durability, and colour, is very much like lava dug from the bottom of a quarry; which has induced many men to give the name of basaltes to the currents of lava: a denomination I am not inclined to adopt, because, not only the basaltes, especially that of the Giants' Causeway, is so

compact that the eye perceives no vacuity in its substance, whereas lava is evidently porous, but there is still a much more essential difference between that and lava; for basaltes has no mixture of any metal, and lava, on the contrary, particularly that at the bottom, is always amalgamated. The denomination, nevertheless, seems generally admitted, with a distinction that has been introduced, of jointed, crystalized, or prismatic basaltes, and of not jointed or common basaltes. Of course the lava must be of the latter kind.

The Giants' Causeway is all of jointed basaltes; that is to say, 1st. That each column in it presents separately a regular solid body of three, four, five, and even so many as nine faces; but the figures most usual are, the pentagonal, hexagonal, and heptagonal. The common height of the columns is forty feet above the ground; the depth below has not been inquired into, and the diameters are from a foot to two feet and a half. 2dly, That each column is composed of distinct pieces, the shape and dimensions of which are always equal, and

exactly fit the hollow, in the pieces adapted to receive the lengthened and rounded extremity of the piece which joins into it. Each of these pieces is nearly a foot; so that in general the height may be known from the number of pieces. 3dly, That immediately next to a pillar in which the convex part is above the concave, one is frequently found that has all its joints directly the reverse; that is to say, the concave parts are on the contrary above the convex. These particulars are given in a discourse on crystalization, by Dr. Alexander Eaton, in the Memoirs of the Literary and Philosophical Society of Manchester.

The regularity of this admirable structure goes even farther. There is a point where, in a sinking of the height, fifty of these columns appear disposed in such a manner that the highest, which is forty feet high, and has forty-four joints, stands in the centre, and the rest, to the right and left of it, slope off gradually till they meet the line on each side. From which appearance, that part has been called *the Organ-Pipes*.

There are other peculiarities in this causeway, which some may think interesting; but I have confined myself to what seems to me sufficient to give an idea of it. Two fine prints were published by Mr. Drury, presenting different views of the Giants' Causeway. Productions of a similar kind are found in Merionethshire, and in some of the Hebrides or Western Isles. Sir Joseph Banks conjectures that the small island of Staffa, one of the Hebrides, thirty leagues North of the Giants' Causeway, is a mass of basaltic prisms. They are to be found in many other places, but no where on so large a scale as in the county of Antrim.

§ 89. The learned have endeavoured to trace the manner in which nature proceeded in this astonishing work. Some have ascribed it to the action of water, others to that of fire: which verifies the saying of the wise man, "That the Creator had so concealed his means in the formation of the world, that they will remain for ever a subject of dispute among men."

In the warmth of the discussions on the origin of the jointed basaltes, the naturalists divided

themselves into *Neptunians* and *Vulcanians*. They who judge it to be produced by water, rely chiefly on the formation of rock-crystals by an effect of the transudation of the liquid through certain kinds of stone; in which manner, for instance, the finest crystals known in the world are created and regularly figured, by the mysterious operation of nature, at the bottom of vast caverns, near Antongil Bay, to the North-east of the Island of Madagascar. The Abbé Rochon, who has been at the place, says that their enormous masses almost approach upon the fabulous. We are informed by M. de Kerguelen, in his Account of the Marine of France, published in 1796, that some of them are white and some of rose-colour. Their sides are all perfectly regular. But allowing that these productions are similar in the exterior configuration with the jointed basaltes, it must be allowed also, that in every thing else they have so many and such essential differences, that each is distinct from the other, and constitutes a different species; and that consequently nothing can be concluded of the generation of the one from the generation

of the other. Let me observe, by the way, that it is near the places where these magnificent rock-crystals are formed, that the valuable tree called the Finguiere is to be found, the milky juice of which, congealed, produces the singular substance which we are acquainted with by the name of *elastic gum*.

The *Vulcanians*, far from ascribing the formation of jointed basaltes to the tranquillity of transuding water, affirm on the contrary, that it has been generated in the turbulent crucible of volcanoes: that it is no more than a species of lava there impregnated with salts and minerals, of properties fitted to give a figure to the mass, such as it appears either internally or externally when the heat goes off; that is to say, when the shape is fixed by the passing away of the fire; as we see all salts crystalize, each in its way, by the evaporation of the water. But here the *Vulcanians* differ among themselves, some holding that a coalescence of water was necessary to produce the effect, and that consequently it was not till after the fall of the inflammable matter to the bottom of the sea

that this kind of lava was generated ; and others maintaining that, considering the nature of this lava, the action of the air was enough to effect its crystalization.

Although the mention of the different opinions of naturalists, on the origin of basaltes, is suitable to the subject of this treatise, it is not necessary that I should enter into the discussion of these two opposite systems ; from which I therefore abstain, confessing at the same time that it would be a task to which I do not think myself equal.

Farther, all the *Vulcanians* agree, that no volcano now produces jointed lava. An observation, which is the more striking, as we are obliged to allow them that this particular kind of substance is vastly more abundant near burning volcanoes, or those acknowledged to have been so, than any where else. And for this reason the *vulcanian* philosophers have asserted, that where basaltes is found it may be considered as a sufficient proof of volcanoes having existed there.

However unwilling I am to adduce facts on

this subject, which I can support only by my own authority, I shall here mention a phenomenon which seems favourable to the hypothesis of the *Vulcanians*, but I will not presume to give an opinion on so doubtful a point. Near a place called Coteuge, about four miles and a half from the town of Besse, mentioned before, § 84, there is a mountain which seems to be entirely formed of a prodigious mass of jointed basaltes. It stands opposite to another mountain evidently a volcanic one, in the ruins of which is a curiosity, found also in several of the extinguished volcanoes of Sicily : there are numerous apartments of very antique appearance dug within the mountain, on the side that fronts the South, where it is perfectly perpendicular. It is not possible to go up to them without the assistance of long ropes : but in some parts there are winding stairs cut within the burnt rock, which lead from one story to another. The places where the inhabitants slept are to be seen, and troughs which were probably for their goats. These apartments, and all the adjacent country are remarkably curious.

But to return to the basaltic mountain: although it is separated from the volcanic one, only by a vale fifty paces wide, through which runs a considerable stream, it has certainly never been burning. A quantity of matter ejected from the neighbouring volcano is found at the foot of it, and here and there on the sides, but it has no marks of a fire having pertained to itself: the earth and sand upon it, which in several places cover its basaltic columns, are in every respect of the nature of common earths and sands. The columns are of a white grey colour: they bear no signs of fire, and the grain of them is entirely different from that of lava, particularly the lava of the neighbouring volcano, of which a great abundance has been emitted. They all here lie horizontally, as they do in some beds found near Etna. They are commonly of the heptagon form, and almost all of them are a foot and a half in diameter. One would imagine them shaped with the chisel. The side of this mountain, which looks towards the volcano, and the foot of which is bathed by the stream, being very steep, the astonishing

mass of columns is there seen very distinctly. It is also on this ascent, which is very difficult to climb, that quantities of it are seen which have rolled down the steep from their original places.

As there are men of great authority who espouse the opinion of basaltes being the production of fire, it was incumbent upon me to state the grounds on which they go in placing Ireland among the countries that have had volcanoes. I shall make but one reflexion, in which the reader has probably anticipated me, and that is, that this strange and astonishing work of nature seems exhibited purposely to mock and defy all systems.

CHAP. XXV.

*The volcanoes known to be burning on the globe.
The volcanoes on the Continent and in the islands
of Europe.*

§ 90. **T**HERE is no fear of mistaking volcanoes which are burning; they appear in a state that admits no doubt. The persons into whose hands this little Treatise may fall, may wish to be informed of their number, and of their situation on the globe; and to satisfy them, I shall here give a list of those that have come to my knowledge. It is fuller than any I have seen, but I do not presume to say that there may not be others. For the existence and names of those that are not so well known as the generality, I shall cite my authorities.

For the sake of order in this long nomenclature, I shall divide the List of Volcanoes accord-

ing to the four quarters of the world, distinguishing in each, those of the Continent, and those of the islands; and in enumerating those in particular places, I shall take them from North to South.

VOLCANOES IN EUROPE.

§ 91. *On the Continent.* *Vesuvius* is at present the principal volcano burning on the Continent of Europe. Varenius says, that near *Apollonia*, to the North of the ancient Epirus, in the present country of Albania, on the Adriatic Sea, there is a lofty mountain that emits fire and smoke. We took notice of this mountain in § 51.

Olaus says, that there are volcanoes in Lapland, and that they are very violent, but I find he is the only author who mentions them.

In Islands.—In describing, § 40, the very singular state of Iceland, we spoke of the seven burning mountains, or Jokells, as they are called in the language of the country. These are *Æcraise*, or Oraife; *Krafte*, to the North-east of the island, remarkable for the great

quantity of vitrified substances which it ejects ; *Portland - Boukt, Kotlegow, Hecla, Shaptan-Glauer, and Westeriackel.*

Three of the Eölian, or Lipari Islands emit fire. These are *Stromboli, the Little Volcano, and the Great Volcano*. Stromboli is distinguished from all the other known volcanoes, on account of its continual emission of flames, without having had the usual volcanic eruptions, at least for more than two thousand years. But, as we have already observed, § 60, the substances deposited about it prove that it has been subject to them. At the North of the island no bottom can be found to the sea. *Houel, vol. i. p. 132.*

Etna, or *Gibello*, it is well known, is in Sicily. The Arabs gave it the latter appellation, which signifies emphatically the mountain.

The island of *Milo*, about twenty leagues to the East of Santorin, both in the cluster of the Cyclades in the Archipelago, has a volcano, whence smoke with sparks continually issue, and sometimes flames. Fire shows it-

self in every part of the island. Hot and boiling springs, and chalybeate, or sweating baths, are very common. They build only with lava at Milo.

CHAP. XXVI.

Volcanoes on the Continent and in the islands of Asia.

VOLCANOES IN ASIA.

§ 29. **ON the Continent.** We have already in section 44, spoken of the five volcanoes that are burning in the South of Kamtchatka ; namely, *Kamtchatkaïa*, *Tolbatchia*, *Joupanouskaïa*, *Chevelitche*, and *Awatcha*. We have also mentioned that, according to the different authors whom we cite in the same section, there are other volcanoes also burning in the northern part of the peninsula, but that none of them were described either by name or situation. Count Beniowski merely says, that they amount to twenty.

Varenus mentions volcanoes at the distance of several days march to the East of the Oby, and others again on the River Pesida. These

are probably the same, the situation of which Baudran fixes more decidedly towards the sources of the Jenissea, and their precise number only at three. They will be found, then, in the part of the Altai which separates the States of the Contaisch or Great Khan of the Eluths from those of the Vang, or Khan of the Kalkas, in lat. 50°, lon. East 117°. These not being mentioned by M. Pallas, we do not consider their existence as certain. Father Martin Martinius in his Chinese Atlas, says, That there are volcanoes in *Thibet*, *Indostan*, and *Camboja*, but does not point out their situation more particularly. We find his authority quoted and adopted in Kircher's *Monde Souterrain*. Liv. 4. sect. 1. chap. 6.

Mount *Chimæra*, called also Goranto, is in the South-east of Natolia Proper. We noticed it in § 24.

We read in various authors that several mountains in Persia emit fire. I do not, however, remember to have seen any other ascertained than Mount *Elbours*, towards the eastern extremity of the province of Irak-agemi, in

latitude thirty-three; and *Cophant*, in the Chorasán, a province to the North-east of Irák: the latter is said to be subject to very violent eruptions.

§ 93. *In Islands.* In this enumeration, I shall consider all the islands West of the Kuriles, as belonging to this quarter of the world, and those to the East of them, as belonging to America.

We have already mentioned, on the authority of Mr. Kracheninnikow and Mr. Tooke, seven volcanoes burning in the Kurile Islands; namely, *Alaid*, *Poromousir*, *Ikarma*, *Tchirikoutan*, *Rakkok*, *Etopow*, and *Montova*. They stand, as we said, very near one another.

We know of ten volcanoes in the Japan Islands. Nippon, the most considerable of the islands, contains six of them: *Jelchus* to the North; *Sineparama*, near Meaco, the residence of the Dairo; these are mentioned by Baudran. Bruzen de La Martiniere speaks also of *Aso* and *Figo*, in the province of Figo; *Fesi*, in the province of Suruga; and *Unsen* near Simabara. In La Peyrouse's Voyage, notice is taken of *the*

Isle of Volcano, about sixty leagues South of Jodo. *Ku-Kusima* is a small island with a volcano, not far from Firando. Opposite to Satzuma is the *Isle of Fire*. Lastly, to the North of the *Lekyo Isles*, in the part subject to Japan, there is a *volcano* mentioned in La Peyrouse's Voyage.

In the same work, we find mention made of the volcanoes that follow, in the cluster of the Mariannas, or Ladrone Islands. In the island called *Volcano*, lat. 38° , lon. East 163° . In an island without a name, same lat., lon. 165° . In the island of *St. Francis*, lat. 27° , lon. East 166° . In the island of *St. Anthony*, same lat. fifteen leagues more to the East. The volcano of *St. Denis*, near the 25th degree of lat., lon. East 164° . In another island called simply *Kolcano*, same lat., lon. East 165° . In an island called *the Great Volcano*, lat. 24° , lon. East 166° . In the island of *Assumption*, lat. 20° , lon. 163° . This volcano never ceases vomiting a sulphureous smoke, the smell of which is perceived for more than a mile and a half at sea. In

another island, also called only *Volcano*; lat. 23°, lon. 178° West. The longitude shows it to be out of the cluster of the Ladrões.

It is agreed by all writers on the subject, that in the Philippine Islands, which are reckoned to be nearly twelve hundred in number, there are many volcanoes. I have, however, never seen more than five of them pointed out: three in Luzon, the principal island; of these one is at *Albay*, another at *Majongo*, and the third, which opened, or more probably rekindled, in 1754, is a *high mountain* in the middle of a lake. The fourth volcano is in the island of *Tandia*: the fifth is pointed out in the island of *Mesindique* by Varenus.

It is said that there are volcanoes in the Carolina Isles, or New Philippines: but I have found no certain reference either as to their situation or their number.

There is a volcano at *Ormus*, at the entrance of the Gulph of Persia. It is remarkable, that although this island is a mere rock of salt, the subterranean fires burn it up to that degree,

that there is no water on it, and the inhabitants are obliged to supply themselves from the Continent.

The *Peak of Adam*, in the island of Ceylon, is famous for its height and violent eruptions.

In the History of Sumatra, a very interesting work, by Mr. William Marsden, published in 1783; and on the map which the author has given of that island, we find four volcanoes pointed out. The first is to the North-east near *Apium*: considerable quantities of sulphur are brought from its neighbourhood. This is the volcano which the Malays call Balaluan, from the great quantity of its fires. The second is a few miles from Mount *Ophir*, about the middle in the length of the island. The name of *Ophir* is modern; nor will the reader suppose it to be that mentioned by Solomon. Mount *Ophir* was measured by Mr. Robert Nairne in 1769, at the time of the transit of Venus over the solar disk. That gentleman, who afterwards perished in an engagement at Sumatra in 1775, found this mountain to be thirteen thousand eight hundred and forty-two feet high from the level

of the sea ; and the volcano which is near it only thirteen hundred and seventy-seven feet lower, which still leaves the latter more than four hundred yards loftier than Etna. The third volcano is near *Indrapour*. These three are not far from the Ocean. The fourth is at a greater distance from it, and is situated at about fourteen leagues from Fort Marlborough near *Bencoolen*.

Mr. Marsden, who lived several years at *Sumatra*, observes, that springs of naphtha or petrolium are common there ; that that of Pedir is celebrated by the Portuguese writers, for its medicinal qualities ; that there is a vast quantity of sulphur in the island, and that the mountains are prodigiously lofty, and full of granite.

I have read in various authors, that there are several volcanoes in the great island of Java, but I find only one pointed out, which is that near *Panarucan*.

Borneo is one of the largest islands in the world : its extent, its very mountainous surface, and its situation among a multitude of islands in which there are or were volcanoes, may make us

presume that several of its summits are volcanic. But it is known that the numerous nations that inhabit it prevent Europeans from going into the interior of the country, and that they scarcely suffer them to land upon their coasts.

Ternate, Tola, Sorca, and Gounapi, are in the Moluccas. The three first take the name of the islands in which they are situated : the last is in the island of Banda. Between Timor and Ceram, in lat. $6^{\circ} 36'$ South, there is a high burning mountain *in a small island*, which was seen by Dampier in 1699. See *vol. iii. chap. 3. p. 88.* Captain Bligh, in his interesting Account of his Voyage in the South Sea, saw a volcano, on the 22d of August 1789, on a lofty mountain in the island of Flores, or Mangerye, thirty leagues to the West of Timor. It seems to be subject to formidable eruptions, judging from the observation of that exact navigator, that the soil of the island appears absolutely burnt. I believe that there are others in the Moluccas; but my inquiries have not enabled me to ascertain any more. We have seen, § 82, how that of Machian was ex-

tinguished in 1646; and in § 83, how that of Timor was replaced by a lake in 1638.

In the third degree of South latitude, and about the 165th of longitude East, is a *burning island* on the western coast of New Britain, at the entrance of the straits which separate it from New Guinea. The volcano upon it was in eruption when Le Maire and Schouten saw it. It was also noticed by Dampier, as was likewise *another* to the East of New Guinea. Baudran places *three others* hereabouts, but does not name them. Dampier in 1700 saw *two* on the island of *New Guing* itself, one of which was at the time in violent eruption. *Fol. iii. chap. 4. p. 131 and 152.*

CHAP. XXVII.

*Volcanoes on the Continent and in the islands of
Africa.*

VOLCANOES IN AFRICA.

§ 94. **ON** *the Continent.* Kircher says, that there are only eight volcanoes known to be actually burning on the Continent of Africa. *Two* in Monomotapa; *four* in Angola, Congo, and Guinea; *one* in Abyssinia, and *one* in Lybia: but he adds, that the vestiges of those which have existed, show that there has been an immense number of them. I suspect that that of Lybia is the same as the cavern of Beniguaezeval, of which we spoke in § 18.

In Islands.—In the islands to the West of Africa, supposing with most geographers, the Azores to be African Isles, we have to reckon in them *Fayal*, *Pico*, and *St. Michael*; in the

Canaries, *Palma* and *Teneriffe*; and *Fuego*, in the Cape de Verd Islands. There is a volcano in the island of *Ascension*, lat. 7° South, lon. 7° East. To the East of this quarter of the world, we have *Fibbel-tier*, or Zibbel-tier in the Red Sea, of which we spoke in § 13. The *Red Mountain*, or volcano of the Isle of Bourbon, and that of *Amsterdam*, are in the Indian Ocean. The particulars of an eruption of the volcano in the Isle of Bourbon, which took place in 1787, were published by Mr. Brunel, who was an eye-witness of it. The lava continued running into the sea, from the 24th of June to the 1st of August.

CHAP. XXVIII.

The volcanoes of America: first, those of the northern part; 2dly, those of the southern part; 3dly, those in the islands corresponding to the Continent of the New World.

§ 95. **T**HE volcanoes of this quarter of the world are so numerous, and it is, besides, so vast itself, that in the present enumeration I shall divide them into those of the Continent of North America, those of the Continent of South America, and those of all the American islands.

VOLCANOES IN NORTH AMERICA.

Bruzen de la Martiniere mentions a volcano in *Greenland*. A Venetian navigator, Barthelmy Zeneti, who knew it, saw at a little distance from the mountain a Dominican Convent, which was built of the lavas of it. Near it were

very copious springs of boiling water, which was used for culinary purposes, and it served by means of pipes to warm the cells of the Monks. The situation of this volcano is not mentioned by any other author. Blefkenius in his Description of Iceland, page 58, says, That at Bestede, the residence of the governor of the island, he met with a Monk of this Greenland monastery, who related to him the particulars we have given of it. This volcano is certainly the most eastern one of this quarter of the world, and probably also the most northern.

In latitude 61° , longitude 137° West, Capt. Cook saw *a volcano*, which is now laid down in all the charts.

In La Peyrouse's Voyage, it is said, that Don Maurelle in August 1779 discovered *a volcano* in latitude 59° , longitude 133° West, which was higher than the Peak of Teneriffe.

Another of prodigious height was seen by Captain Cook, at the point of *Alaska*, in lat. 55° , lon. 148° West.

In the same latitude, but in longitude 121° West, Don Maurelle discovered *volcanoes* on

the 24th of August 1775. This is mentioned in La Peyrouse's Voyage.

It is said in the same work, that that Spanish navigator fell in with one in lat. 41° , to the North of Cape *Mendocin*.

Father Alexander Perez, in his History of Mexico, points out *five in California*; of which three are in the interior of this great peninsula, and two on the coast.

The following belong to Mexico: the three first and the Devil's Mouth excepted, which are towards the North Sea, they are all at a very little distance from the South Sea.

Popocatepec, near Tlascala.

Popocampeche.

Colima, of which we spoke in § 11, in the province of Mechoacan, near the 19th degree of latitude.

Between this point and latitude 12, a space of only seven degrees, a hundred and forty leagues, are situated the volcanoes of

Acapulco, to the South-east, near the town, the name of which it bears, and which it has lately destroyed;

Soconusco;

Coatlan; See Baudran.

Mano-Blanco, near Truxillo in Honduras; this has opened or revived since 1764, See *post* § 106;

Las Amilpas;

Sapotitlan;

Sacatapec, or Suchitepec;

Atilan;

St. Jago de Guatemala;

Isalcos;

Sonsonate, or the Trinity;

San Salvador;—See Baudran—

Cataculo;

St. Michael;

Cocibina;—See Danville—

Vigo, or Vejo Volcano;—Danville—

Telica;

Granada;

Pico;—Danville—

Anion;

Montbacho;—See Baudran—This is the Bombaco of Rogers—

Nicaragua; called also St. Leo, and Masayatan—

The Devil's Mouth.

The volcanoes, opposite to which I do not put the name of the author who mentions them, are all named by Bruzen de la Martiniere : not that I mean to say, they are not cited by others. This observation I beg may be considered as general.

§ 96. VOLCANOES IN SOUTH AMERICA.

In New Grenada. Velez, forty-five leagues due North of Santa Fé de Bogota. See Danville.

Tocaima, six leagues North-west of the same city.—Baudran.

In the province of Popayan. Cocomucos, or Cucunico, twenty leagues East of the town of Popayan.—Baudran.

Los Pastos, or Catambuco, thirty-six leagues South-east of the same town.—Baudran.

Quimbaya, or Cumbal, fifteen leagues South of Catambuco.—Baudran.

In Peru.—The volcanoes in Peru, except the last, stand very near one another. They are situated between the first degree of North lati-

tude and the fourth of South latitude; and from lon. 55° West to lon. 62°. I shall here give them as nearly as possible in the order proposed.

Carappa, or Cayapas.

Pichinca, at the foot of which the city of Quito is situated.

Maspa.

Cotopaxis.

Coca.

Sinchonalagon.

Antisana.

Pinta.

Cargavi-raso, or Carguayraso; which vomited a frightful torrent of mud in 1698. See Voyage Historique de Don Antonio de Ulloa, vol. i. page 267.

Corason.

Illinicas.

Ygualaga, on the River Bamba.

Chimboraso.

Malahallo.

Sangay, or Songai, called also Macas.

Lucanas, which opened or rekindled in 1746,

at the time that Lima was destroyed. Don Antonio de Ulloa. Vol. ii. part 2. chap. 9.

Arequipa, lat. 17° South; lon. 55° West; three or four leagues to the North of the town of the same name.

The greater number of these volcanoes are mentioned by Mr. Valmont de Bomare. All the others may be found in the different authors already cited.

Danville has laid down upon the map of Chili the volcanoes that follow, from lat. 27° South to lat. 47° , and between 48° and 53° West longitude.

Copiapo. From the mines in the neighbourhood of this volcano, and from those of Guasco, a little more to the South, comes the purest gold known, that called *Capot Gold*.

Coquimbo.

Chuapa.

Ligua.—It is probably this volcano that causes such frequent and such violent earthquakes at Valparaiso. Admiral Byron, on whom, in spite of his great talents, Fortune seems always to have frowned, spent a few days at two differ-

ent times in that town, in the course of the two years that he was detained a prisoner in Chili, being then only a midshipman, cast away in the Wager, one of Lord Anson's squadron. Each time, while he was there, he felt a violent earthquake. *See his Narrative, pages 160 and 181. Ed. 1785.* Although this volcano is thirty leagues distant from Valparaiso, East-north-east; yet, besides its great elevation in the Cordilleras, it extends its branches to the neighbourhood of the town.

Peteroa.

Chillane.

Antoco.

Notuco.

Villa Rica.

Osorno.

Chuanauca.

Quechucabi:—Admiral Byron, whom I have just before cited, was in 1742 at Chaco, the capital of the island of Chiloe, when this volcano had an eruption. This mountain, says he, without giving it a particular name, but distinguishing it as that opposite Chaco twenty

leagues to the eastward, vomits torrents of flames, and its eruptions are frequent. See *Byron's Narrative*, page 152. Ed. of 1785.

Minchimavida.

St. Clement.

Baudrān mentions all these volcanoes, except Minchimavida: but adds to the list *Auton*, in the province of Chucuita, and three more quite to the South, with the names of which he says he is unacquainted. Rogers, who had often been on the coasts of Chili, says in his *Voyage round the World*, page 346, that there were sixteen volcanoes actually burning in that vast region; but he does not mention their names.

§ 97. VOLCANOES IN THE AMERICAN ISLANDS.

The islands of America are so prodigiously scattered, that I shall divide the list of their volcanoes into three parts; 1st. those that lie to the West; 2dly, the two to the South; and 3dly, those to the East.

First, islands to the West.—Mr. Tooke, in his work which I have already quoted on the subject of the Kuriles, says, that four of the Fox

islands, to the southward, and very near the great point of Alaska abovementioned, have each a volcano actually burning: namely,

Ouminga.

Ounalska.

Omnak.

Goreloi, near Tagalun.

He mentions two in the Aleouski Islands, to the southward of the foregoing: namely,

Kanaga.

Takavanga.

There is a volcano in the Island of *Trinity*, lat. 56° North, lon. 137° West.

Baudran places one in *Sesarga*, one of the Isles of Solomon, lat. 10° South, lon. 160° West; and another in the *New Hebrides*, or Archipelago of Santo Spirito, near Santa Cruz.

I find three laid down in the Friendly Islands.

Tofoa.

Kao.

Tana.

Captain Cook, who saw the first of these volcanoes, in May 1774, observed, that it was very lofty, and ejected rocks of a monstrous size from

an immense crater. We are told by Captain Bligh that it scarcely ever ceases throwing out flames, and that all the country about it is covered with its lava. See chap. 14, of his interesting Narrative. It was in sight of this island in April 1789, that the major part of his ship's crew mutinied, and putting this ingenious navigator and those who adhered to him into the pinnace, set them adrift in the Pacific Ocean. The volcano of Tana was in a state of eruption on the 15th of April 1793, at which time it was seen by the frigate that was sent in search of M. de La Peyrouse. The author of the Narrative tells us, that it made a very beautiful appearance at night. I presume that there are other volcanoes in the vast multitude of islands scattered over the great Pacific Ocean, but no more have come to my knowledge.

2dly, *Islands to the South*.—At the South extremity of the American Continent is the island of *Terra del Fuego*, in which Danville lays down two volcanoes; one nearly opposite Cape Froward, in the middle of the straits of

Magellan; and another in the centre of the island.

3dly, Islands to the East.—Among the Antilles, or Leeward Islands, the following have volcanoes :

St. Christopher's.

Nevis.

Guadaloupe.

Dominique.

St. Vincent.

CHAP. XXIX.

Observations on the general proximity of volcanoes to the sea. What is the cause of it ?

§ 98. **I**N summing up the whole we shall find on the globe a hundred and eighty-nine known volcanoes : of which ninety-nine are on the Continents, and ninety in islands ; namely, in the Old World, two in Europe, eleven in Asia, and eight in Africa ; in the New World, thirty-eight in North America, and forty in South America : in the islands, twelve in Europe, forty-nine in Asia, ten in Africa, and nineteen in America.

It will be remarked with surprise that, notwithstanding the immense disproportion between the surface of the two Continents and that of the islands, there should be so little a difference in the number of their volcanoes,

both Continents containing only a tenth more than the islands.

But on observing farther that nine-tenths of the continental volcanoes are very near the sea, and that they are even seen in Mexico and Chili, where they are so numerous, ranged as it were in a line on the coasts of the South Sea, and following its inflections ~~as so as to~~ stand nearly at the same distance from the Ocean, we readily suspect that there is a general cause for the approximation of the volcanic fires to the bed of the sea.

I do not think that we can avoid acknowledging this, by answering that the present state of them only proves that the activity of the insular volcanoes, and those near the sea being more easily abated by their situation, they must have supported themselves longer than those farther inland on the Continent; and that the former have therefore remained burning, while the latter are extinguished.

It is not to be doubted that a volcano refreshed by a transfusion of the sea-water will last longer, as we have already remarked: but,

after making every investigation, a very great disproportion will still be found between the extinguished volcanoes in the islands or on the sea-coasts, and those extinguished in the interior of the Continents, though not so great as that which we have been remarking.

For, confining ourselves to a summary statement of things, and without dwelling on particulars known, it is in the same seas where the present burning islands are situated that we are shown the islands that were formerly burning : it is on the same peninsulas where we see active volcanoes that we meet extinguished ones. It is in the immense chain of the Cordilleras which run along the Pacific Ocean, a chain where they are still so numerous, that the remains of former ones are found.

Thus substracting the extinguished volcanoes on the Continent, that is to say, 1st. Those in the South of France, as being in the neighbourhood of the Mediterranean ; 2dly, Those of Italy, as being confined between two seas ; 3dly, Those which we mentioned as having been very numerous in Asia Minor and Syria ;

Syria lying along the Mediterranean, and Asia Minor being shut up between three seas, from which circumstance it was originally called the Asiatic Peninsula; 4thly, Those of Kamtchatka, as being also on a peninsula; and 5thly, Those of the Cordilleras near the South Sea; we shall find the number of extinguished volcanoes which can be considered as really continental, very small in comparison with the extinguished volcanoes near the sea, so that it may be affirmed that this marked proximity of the great majority of volcanoes to the sea is the effect of a general cause.

§ 99. This cause must certainly be sought in the sea. I can only find it in the bitumen, salt, and other elements which give sea-water its peculiar qualities. These substances, which are also essential elements of volcanoes, must have been transfused and deposited in cavities within the reach of the sea, and where too already lay, but in an inactive state, the other materials necessary to the formation of a volcano. Hence volcanic openings must have been infinitely more common near the sea than in the remote

regions of the Continent, because in the latter situation they could only take place in the very limited spots where the nature of the soil, by uniting bitumen and proper salts, supplied the deficiency of the sea-water in that quarter.

CHAP. XXX.

An extinguished volcano may be rekindled. Vesuvius, after lying apparently extinguished for several centuries, took fire again in the reign of the Emperor Titus. The death of Pliny the naturalist. Vesuvius, after burning about a thousand years, was again apparently suppressed.

§ 100. IT has been asked whether volcanoes once extinguished can again take fire. To avoid all ambiguity, let us premise that a volcano is judged to be extinguished, when for ages neither fire nor smoke has been emitted from it, when its crater is totally closed up; and when, in short, from its exterior state it is again included in the common class of mountains. The question as to taking fire again relates to such an old volcano as this.

Why should it not take fire again, if the

cause that occasioned its extinction ceases? Let us call to mind four of the five causes which may occasion the suppression of a volcano: 1st. The mines being exhausted:—but in time they renew themselves. 2d. The falling-in of the greater part of the vault, or a large chasm in its sides:—this cause would perhaps be the most difficult to overcome; however, the fire preserved in distant and covered recesses may again work up the fallen masses, join them by baking, and raise them from the bottom of the abyss, where the interior form still subsists, I mean the funnels or chimneys. What we shall observe of submarine volcanoes will prove, that this effort is neither impossible nor extraordinary. Some sensible observers assert, that the higher region of Vesuvius was raised in this manner from the bottom: the same is said of the Peak of Teneriffe. 3d. All the cavities of a volcano may be overflowed:—but they may be emptied by some fortuitous event. 4th, The water which was necessary to it may be lost:—but an earthquake is enough to change the course of the streams. These it may be said

are barely possibilities. Granted, but the question is reduced to that of possibility. Kircher says more decisively, that a number of extinguished volcanoes only wait for a restoration of the inflammable substances to resume their fury.

§ 101. Besides, nature herself furnishes us with proofs to show that these possibilities are not altogether chimerical; and if we had not been inclined to point out the manner in which it is probable she acts, we might have confined our answer to the simple statement of facts given by history, as that would have been sufficient for the purpose.

In the reign of the Emperor Titus, Vesuvius was considered as having been for ages reckoned in the number of simple mountains: it was distinguished among them only by its astonishing fertility. Being near Naples it was very much frequented. It is true, that men of science suspected it to have been burning in remote times.

Vitruvius, who flourished in the middle of the reign of Augustus, says, book 2. chap. 6., that *according to history, Mount Vesuvius had*

formerly been burning, and that it had covered all the adjacent places with its fires. And a little lower, speaking of the pumice-stone, common near that mountain, he observes, that it is found only near Etna, and towards the hills of Mysia, in those places, says he, which the Greeks call burnt country. These are the same spots we mentioned before, § 25, by the same name, according to Strabo.

Diodorus Siculus, who wrote in the end of the reign of Augustus, and in the beginning of that of Tiberius, relates, book 5. chap. 21, that *Hercules saw Vesuvius, which at that era vomited fire like Etna. In fact, adds he, it retains many vestiges of it. The era of Hercules is anterior to the vulgar era near thirteen centuries.*

Strabo, who was contemporary with Diodorus Siculus, after describing, book 5, the top of Vesuvius *as barren, of ash colour, containing caverns full of gaps, and that the stone of it from its smoky appearance indicated that it had been consumed by fire, adds this reflexion; so that it is natural to conjecture that this mountain was*

formerly a volcano which has been extinguished from the want of fuel.

Silius Italicus, who lived under Nero, says, that *Vesuvius had formerly by its volcanic fires caused great ravages both on the land and at sea.*

Valerius Flaccus, in his Poem on the Argonautic Expedition, speaks of *thundering eruptions to which Vesuvius had been subject.* He dedicated his poem to the Emperor Vespasian, who died on the 24th of June in the year of our Lord 79, and it was on the 24th of August in the same year that Vesuvius again broke out.

On the same day Herculaneum, Pompeii, and Stabiæ, were buried under its ashes. Tacitus, in the first book of his Histories, glancing at this misfortune, says, *that the eruption was a new calamity, or one at least that had not happened for a long series of ages before.*

The discovery of these towns, which has been made almost in our own times, *has ascertained* what was presumed by the six authors we have just cited: for they were built and paved with

the same sort of lava still used at Naples and Portici.

§ 102. Pliny, the naturalist, who was a prodigy of learning, lost his life by this horrible event. He had the command of the Roman fleet on the coast of Campania. Solicitous to save such persons as might choose to fly by sea, anxious also to prevent the depredations likely to be committed by ill-disposed persons, and induced moreover by the hope of some instruction respecting this grand phenomenon, of which the cause was still unknown, he left the Cape of Misenum, and undaunted approached the side of the bay where this dreadful disorder of nature prevailed. He landed and advanced too far : thick whirlwinds of sulphureous vapours fell around him and suffocated him.

§ 103. Vesuvius, after burning from this renewal nearly a thousand years, became again apparently suppressed, and remained so for almost four centuries, from 1136 to 1506. The Academy of Naples, in the exposition which it gave to the public of the eruption of 1737, says, that there are proofs that in the twelfth, thirteenth,

and fourteenth centuries every part of Vesuvius was inhabited, and that there was a coppice and pools of water in what is now its crater. It was again an extinguished volcano, and seemed to be so for ever : yet, for three centuries past, and particularly in this, the eighteenth, this very mountain has never ceased giving alarm, and has been the cause of dreadful calamities. I say particularly in this century, for it is to be observed that of twenty-nine eruptions which this volcano is known to have had from the reign of the Emperor Titus to the present time, the last fourteen have happened in the eighteenth century.

CHAP. XXXI.

The great antiquity of Vesuvius and Etna as volcanoes. Did the Deluge necessarily extinguish, as has been said, all the volcanoes then burning? Other volcanoes which it may be presumed have been rekindled. Grounds for thinking that Etna has been formerly extinguished.

§ 104. **AT** the foot of Vesuvius there is an inscription which tells us that since the creation of the world, *ab satu solis*, this volcano has rekindled seven times. It is dated in 1631. I believe the author could have had no other foundation for this assertion, than the knowledge of its suppression for some centuries after raging for a thousand years. Hé may have taken it for granted that these events must be periodical, and thence concluded, that in the seventh thousand year of the world Vesuvius had rekindled for the seventh time.

We may depend with greater confidence on the assertion of Mr. Bianchini, a naturalist highly esteemed. In consequence of the profound researches made by him in 1689, he judged that Vesuvius had had eruptions coeval with the deluge. His delicacy perhaps withheld him from saying, that they were anterior ; for the state of all this part of the country of *Lavora* manifests revolutions at least as ancient as those of Sicily. Now, it is agreed among naturalists, on considering the eras in which the most ancient layers of the lavas disgorged by *Etna* seem to have taken place, that this volcano was in a state of conflagration before the general deluge ; even if we allow that to have happened according to the calculation of Don *Pezron*, 5464 years ago, instead of 4092 only, the distance at which it is placed from this period, A. D. 1800, by the chronology of *Usher*, Archbishop of Armagh.

§ 105. Some bold and celebrated writers have, in latter times, ostentatiously made use of this remote antiquity of volcanic vestiges, against the truth of the deluge. Taking it for

granted that that terrible event must have overflowed all the pre-existing volcanoes, and extinguished their fires for ever, they concluded that Etna, being proved to have been burning long before the remotest period assigned to the deluge, had become, by its continuation, indubitable evidence against the Mosalcal account, which, according to them, was nothing more than a fable, or at most a manifest exaggeration.

To consider this assertion only in a physical point of view, it appears to us very superficial : for, besides what we have already said, § 100, of the possibility of the revival of the fires even in such a case as that supposed, do not we know that there are volcanoes burning under the sea ? And can any thing be more plain and natural than to suppose, that several of the volcanoes on the land, which were burning at the time of the deluge, should, in like manner, be indued with sufficient force to struggle successfully against their extinction, by using their craters so as to obstruct the influx of the waters, as we find it done by the submarine volcanoes ?

The volcanoes which were covered by the waters of the deluge were, in fact, for so many months real maritime volcanoes ; and supported themselves like them in the manner which we shall endeavour to explain when we come to treat of the latter, particularly in §§ 130 and 131. Nay, several circumstances must have facilitated that operation : the craters, then less worn away, must have been narrower than they are at present ;—the inside of the volcanoes being also less consumed, the column of resistance must have had more force, and there were more objects to be removed ;—all the inflammable substances were in greater abundance and supplied more powerful efforts ;—the waters of the deluge, though causing effervescence in the fiery reservoirs, flowed in more slowly, and in a less body than do the waters of the sea, and of course the irritation was more easily overcome. These circumstances will have more weight after the reading of the sections just mentioned.

That several volcanoes on land existed anterior to the deluge, is a position therefore very ad-

missible. The effect of the first eruption, after the retiring of the waters, was the restoring them suddenly to their former state. Thus we see this detraction of the sacred writings arises from a want of attention in those writers to an operation common in nature, and which in this particular circumstance could not fail to occur in a number of places.

§ 106. The Canary Islands have been resorted to for four centuries past: Palma, one of them, showed by its lavas that there had been volcanoes in it, but from the time of its discovery there was not any in an actual state of conflagration till the year 1652, when one suddenly broke out, which still exists. Is there any doubt that this was a volcano rekindled? No account has been given of the state of Manó-Blanco, mentioned in § 95, previous to the period of its eruption in July 1764. In the country where it is, it was thought to be the first eruption of the mountain. Its fires made dreadful havoc: a hundred and eighteen houses, scattered on the part over which the matter poured, were destroyed; many persons perished;

a number of wild animals fled from the woods which covered the mountain, and in their fright took refuge in Truxillo, where they were killed in the streets. These particulars are taken from the public papers of that time. It is very possible that this explosion may, in fact, have been the first of this volcano, the final circumstances necessary to cause its conflagration not happening till then. But it might likewise be presumed, from the great quantity of subterranean fire existing in Guatemala, which is near it, that the eruption of Mano-blanco at that period was the renewal of a conflagration which had been suspended for several centuries, and if so, the suspension certainly commenced previous to the discovery of America. There can be nothing decided in this case but by an inspection of the country.

For sixty years after the discovery of the Eastern Asiatic Islands, the same security prevailed respecting the situation of Mount Gounapi, in the island of Banda, and of Panarucan, in the island of Java: they were known, and it was evident that they had been burning, but

they excited no apprehension, when their craters again opened in the same year, 1586.

We have already mentioned, that according to the public accounts of the late convulsions of Peru in 1797, extinguished volcanoes were rekindled between Lygualaga and the Macas, or Sangai.

What a multiplicity of facts might we have to add to this theory of the rekindling of volcanoes, could we trace the history of a greater number of them farther back? The knowledge, however, to which we are limited, suffices, as we see, to establish the affirmative. It would be proved, were we entirely reduced to Vesuvius and Etna; for, by the certain accounts which we have of these volcanoes for nearly three thousand years, it is known that the former has been rekindled twice in that space of time, after being for ages, to all external appearance, extinguished; and that if we cannot say as much of the latter, it is because, for these three thousand years it has never ceased producing its fires. This at least is the common opinion; but there are learned men who assert, that

Etna lay in a dormant state for some centuries.

§ 107. In fact, Diodorus Siculus, a well informed writer, and who must have been particularly conversant with the facts relative to the history of his own country, mentions an eruption of Etna five centuries prior to the Trojan War, that is, about 1700 years before the Christian era. Now, Homer, who wrote eight centuries after that eruption, who had travelled much, and particularly in Sicily, and whose almost universal knowledge we contemplate with wonder, does not even mention this volcano, either in his Iliad, notwithstanding the grand images he might have drawn from it, or in his Odyssey, although he lands his hero in Sicily upon the very coast inhabited by the Cyclops, whoever those wild people may have been, a coast over which the lava of Etna has often run, as recounted by Virgil in the first book of the Georgics :

— *quoties Cyclopum effervere in agros*

Vidimus undantem ruptis fornacibus Ætnam,

Flammarumque globos, liquefactaque volvere saxa.

— Now oft have we beheld
Loud thund'ring Etna from volcanoes burst,
Deluge with liquid fire Cyclopean fields,
And toss huge balls of flame, and molten stones.

TRAPP.

From the silence of this sublime Poet, it has been inferred, that this volcano was not burning in his time, and that it had then been dormant from a period much remoter still. Though this is but a simple inference, it must be allowed to be a very strong one. This mountain was again rekindled: Pindar, who lived about five centuries after Homer, speaks of its eruptions, and we have in Thucydides the particulars of that which took place in the year 476 before the vulgar era.

On the whole, this presumed extinction of Etna, and its long slumber anterior to the age in which Homer flourished, appear less extraordinary after what we reported in § 46, on the authority of Dominico Galliano, that the crater of this volcano, in consequence of a rest of eighty-nine years, in the fifteenth

and sixteenth centuries, had closed up and become solid, so that people walked over it, and its fires were supposed to be extinguished.

CHAP. XXXII.

Of the Mud-Volcano at Maccalouba. Its extraordinary eruptions. The manner in which this phenomenon may be explained.

§ 108. **OUR** subject having brought us back to Sicily, and as it is probably for the last time, we will not leave this island without speaking of a very extraordinary phenomenon to be seen in it. It is connected by striking affinities to the subject of this treatise : it has volcanic motions, even the great convulsion of eruptions ; in a word, it is a volcano, and bears the name of one ; but, what will not debase the consideration of it in the eyes of a naturalist, it is a volcano of mud. It is a strange object, and was the only one of the kind known till the discovery very recently made by Mr. Pallas, of a place in the island of Taman, the properties of

which seem to be similar. We will give an account of them successively, beginning with that of Sicily.

Between Arragona and Girgenti, near a place called Maccalouba, there is a hill, in the shape of a cone, with the top broken off, a hundred and fifty feet high. The summit is a plain of half a mile round, the whole surface of which is a thick mud, yet not so firm but that it sometimes occasions a fear of sinking into it. There is not the slightest sign of vegetation upon it. The depth of the mud is unknown, but it is supposed to be immense.

In the course of the year this plain presents two different appearances. In the rainy season the mud of it is much softened: it has an even surface, on which there is nothing more to be seen than a general ebullition, accompanied with a very sensible rumbling noise. At this time it is dangerous to go upon the spot. In the dry season, the scene changes: the mud acquires greater consistency, but without ceasing its motion. The plain assumes a form slightly convex; a number of little cones are thrown up,

which, however, rarely rise to the height of two feet. Each of them has its crater, where a black mud is seen in constant agitation, and incessantly emitting bubbles of air. With these the matter insensibly rises. As soon as the crater is full of it, it disgorges; the residue sinks, and the cone has a free crater until a new emission. In this season too, towards the West of this small plain there appear some cavities full of muddy salt-water, from which likewise bubbles of air are thrown up: but here, it is without noise, whereas in the cones the air makes a cracking as when it proceeds from water that boils violently.

§ 109. Such are the regular states of this extraordinary hill in the course of the year: it would probably, however, have obtained but little attention, had its properties been confined to those.

But this phenomenon at times assumes quite another character. The hill is subject to convulsions alarming to all its environs. They are denoted by earthquakes, which are felt at the distance of two or three miles. Internal noises,

resembling the rollings of subterranean thunder, are heard; they increase for several days, and then end in an eruption of a prodigious spout of mud, earth, and stones, which rises two or three hundred feet into the air. This explosion is repeated twice or thrice in the course of the twenty-four hours. Some years the mount has no eruption, but it rarely is the case that the eruptions do not continue yearly five years successively.

As it may be a satisfaction to read an account written by an eye-witness of the explosion of September 1777, I shall here give a short extract of the principal points.

At first a deep, hollow noise was heard, which soon became louder than the rolling of thunder; the earth shook in all the adjacent places, and large chasms opened. From the centre of the plain a body of 'diluted' mire, sixty feet in diameter, issued bubbling, and rising gradually soon reached the height of two hundred and thirty feet. This phenomenon lasted half an hour: it was thrice repeated with an interval of a quarter of an hour between each eruption,

while a noise like that made by the sea in a storm was continually heard under ground.

The author of this account took the first moment it was possible, to approach the point of explosion: he dipped his arm in the place which seemed to boil the most violently, but experienced no sensation of heat, on the contrary, he thought it felt colder; and in fact, the glass fell from thirty-three to thirty.

Fire, then, is not the cause of this phenomenon, for it appears no where in it; the stones and the sand bear no marks of it. But some observations drawn from the nature of the soil may help us to an explanation of the subject.

§ 110. The country around is of a calcareous earth: briny springs and salt mines are found in the neighbourhood: some beds of oil of petroleum are also observed floating on adjacent stagnant waters. It is well known that this oil, wherever it appears, is a sign of there being mines of bitumen near. In the case before us, the vitriolic acid liberating a great quantity of fixed air from the salts with which this argillaceous and limy mass is impregnated, that air is

observed escaping copiously by a general bubbling on the surface of the plain, when the substances are sufficiently diluted by the continuance of the rainy season.

The warm season returning, daily dries these substances layer after layer, and the air has no longer the same power of escaping at the surface. It succeeds indeed at some points; it raises the little cones, penetrates them, and forms their craters in making its passage. But far the greater quantity of the air is concentrated till the return of the rainy season softening the surface, it again breaks through its confinement: its elasticity being restored, it flies off, convulsing and carrying with it whatever continues to impede its re-establishment in equilibrium with the external air. In this manner I think this truly strange *lusus Naturæ* may be accounted for.

CHAP. XXXIII.

Discovery of a phenomenon of a similar kind made by M. Pallas. Its eruption in 1794. How explained by that author.

§ 111. **I**N a very interesting Memoir, printed at St. Petersburg in 1795, under the title of *Tableau Physique et Topographique de La Tauride, tiré d'un Voyage fait en 1794, par M. Pallas*, page 21, there are particulars, of the discovery which we mentioned in the last chapter.

Mr. Pallas introduces this phenomenon as worthy the attention of the curious. He observes, with great reason, that it is more uncommon on our globe than volcanoes are. From this expression, it should seem, that the author was acquainted with some other situation analogous to that of which he was treating: he might allude only to Maccalouba, which, till

then, had been considered as the only one in the world. I do not find, however, that he mentions that or any other.

This phenomenon is less expanded in its formation, and has, perhaps, for that very reason, less effect than that of Sicily. The substances which compose it are situated partly in the peninsula of the Kercha, the boundary of Europe to the South-east of Little Tartary, now Taurida, and partly in the island of Taman, which is separated from Kercha only by one of the mouths of the river Cuban : Taman lies in Asia. Both these places are in flat countries, where there are but few hills, and those very little raised above the level of the sea. The whole is covered with beds of slime mixed with sand, with some beds of marl and sea-shells. From this state alone, observes Mr. Pallas, we may judge that no real volcanic pit can exist here. Copious springs of petroleum are found in several places, and also pools or siphons, of greater or smaller dimensions, through most of which a briny mud is disgorged in bubbles.

The author saw three of these pools in the

peninsula, and seven or eight in Taman. One of the latter, several fathoms in diameter, situated on the side of a hill, shows, by its incessant bubbling, the abundance of gas that keeps it working: the liquid mire is constantly falling over the brim of it, and flowing off slowly. On the top of the same hill are seen three small eminences, which are evidently formed by the mud vomited by three similar pools formerly open. At their foot are two little lakes of salt water, which smells of petroleum. Persons settled at Yenikoul, for fifteen or twenty years past, remember an explosion which took place on this hill, with circumstances similar to another event, which happened in a different part of the island six months previous to the author's journey.

§ 112. This last eruption took place in February 1794. It was the greatest and most copious ever known. It happened at the top of a hill situated at the North point of Taman, near the bay of the same name. The appearance of the place seems to indicate that there had been a similar eruption at a period far back.

The ground not covered over by the last is of the same nature as the more recent sediments; it is the same soil, with the difference only which vegetation and the atmospheric influence must necessarily produce.

The place where the new gulph opened was a pool where the snow and rain-water usually remained for a long time. The explosion took place with a noise like that of thunder, and with the appearance of a *mass of fire, in the form of a sheaf*, which lasted only about half-an-hour, accompanied with a *thick smoke*. The ebullition which threw up a part of the liquid mud lasted till the next day: after which the mud continued running over slowly, and formed six streams which made their way from the top of the hill to the plain. The body of mud collected by these streams is from three to five *archines*, that is, from six to ten feet deep, and may be reckoned more than a hundred thousand cubic fathoms: an effusion which approaches the marvellous! In July, which was the time Mr. Pallas visited the place, the surface of those beds of mud was dry, extremely uneven, and cracked

like clayey ground. The gulph that had vomited them was stopped up with the mud which was likewise dry. It was not dangerous to walk over it, but it was frightful, as the horrid bubbling, which was then still heard in the interior of the hill, showed that its bowels were not so tranquil as its surface.

The mud thus discharged is always a soft clay, of a bluish ash-colour, every where of the same nature, mixed with brilliant sparks of mica, with a small quantity of marly, calcareous, and sandy fragments of schist, which seem torn from the beds directly over the reservoir whence the explosion proceeds. Some crystals and sparkling lamina of pyrites found on these fragments prove, that the heat of the reservoir was not sufficiently powerful to affect the beds which contained those pyrites: nor was the mud discharged from the gulph more than *lukewarm*. The sheaf of fire was probably nothing more than the effect of the phlogistic air, which might have caused the explosion.

§ 113. Mr. Pallas, reasoning on the accounts which had been given to him, judges it likely

that a very deep coal mine had for ages been on fire under Kercha and Taman; that the sea fortuitously breaking into the burning cavities of the mine, the expansion produced by the water turned to steam, and the struggle of the different gas to get free, force the upper beds, break them in pieces, and make a passage. The vapours as they escape carry the mud along with them and drive it out. In this manner is it disgorged. The broken beds, when covering it again, must, in settling, yield a supply for a greater emission, which continues till a general equilibrium is established.

Such is Mr. Pallas's explanation; and it is certainly the best that can be given, if the action of fire be admitted in this phenomenon: but I must say that I very much doubt it. The *appearance of the sheaf of fire* is extraneous. The learned naturalist thought so too. He knew well that it could not proceed from a very deep burning coal mine. Not being an eyewitness of the event, he admits the circumstances as they were related to him; but in his embarrassment considers the fire as an accident

in the phenomenon : "This fire," says he, "was probably produced only by phlogisticated air." The people of Maccalouba likewise thought that they saw flames in the eruptions of their volcano : but it was an illusion, as was there demonstrated ; and I incline to think that the people of Taman also were deceived. There is nothing very extraordinary in this supposition, in support of which a multitude of facts might be adduced.

There seldom passes a century in which some havoc is not made by the falling of parts of the Alps. A mountain which overlooked Pleurs, three miles North of Chiavenna, split on the 25th of August 1618, and the whole side towards Pleurs, having lost its perpendicular, fell and crushed the town and all its inhabitants, to the number of two thousand two hundred. *See the Encyclopedia Britannica, at the word Pleurs.* About five and twenty or thirty years ago, in a similar manner in Savoy, a large part of one of the heights in the Alps rolled down and caused a great deal of damage. The earth was violently shaken, and to a great distance. For some

days it was thought to be a new volcano by many people, who also believed that they saw flames amidst smoke. The Court of Turin, on the general report, sent men of science to the spot, who found it to be a vast but simple disruption, without any mark of fire.

What deceives in these accidents, says M. de Saussure, speaking of the latter event, is, that between dark and extremely convulsed spiral masses of dust, or aqueous vapours, there are spaces left which admit points of light that penetrate and strike the eye with the greater brightness, the greater the darkness which they cross and contrast.

The accumulation of matter in the upper part of the eruption is sufficient of itself to occasion this mistake. There is necessarily a great condensity at the head of the spout, where the matter in its inclination to re-descend is retarded, repelled, and thrown off by the force of that which continues to be ejected, and by the action of the air which issues copiously from the crater: the darkness of the higher part of the mass will, therefore, make the lower part appear

much lighter. This may be illustrated by a comparison.

Mr. Houel was the King's painter : this alone might constitute him judge in the present case, but by his Picturesque Travels through the islands of Sicily, Malta, and the Lipari, in four volumes, folio, 1782, a work which we have already cited, he has acquired in the public esteem more titles than that to which he confines himself. He expresses himself as follows : *vol. i. page 117.* " While I was drawing *Volcano*, " a prodigious quantity of smoke issued from " its crater. The clouds which it formed were " black and thick : they made the column of " smoke thrown up by the volcano appear " whiter, and indeed so bright that it looked " like flame." Wiser people than the Tartars of Taman might have been deceived by an illusion so analogous as this.

We see that this phenomenon both in its essential and accidental qualities is at Taman what it is in Sicily : for I think nothing of the *slight warmth* the matter is said to have

had at the mouth of the gulph. To have formed any judgment of it, must have required the assistance of the thermometer : and it is striking, that finding it, no doubt, cold at the extremities of the streams, the persons who saw this matter bubbling in the gulph should say no more of it, than that it was tepid at that central point. If the phenomenon is confined at Taman to a violent commotion of the matter, to spouts of diluted mud, and a copious emission of vapours, without the eruption of a very high column, by which Maccalouba is distinguished, and if great explosions are more rare, the reason is, that at Taman and Kercha the matter is more scattered and has a greater number of drains, and must consequently act with less effect than at Maccalouba, where it is absolutely concentrated in a point. Were there but one at Taman, the two objects would bear a perfect resemblance, and perhaps there would in that case be more energy in that of the latter situation, where the matter seems to be more abundant,

I am, therefore, led to conclude, that this mud-volcano is precisely of the same kind as the other, and that similar causes produce both.

CHAP. XXXIV.

*The Hydropyric Volcanoes of England. Reflexions
on those Phænomena.*

§ 114. **A**MONG the interesting objects with which Great Britain furnishes the history of Nature, there are two springs, to which naturalists have given the name of *Hydropyric Volcanoes*, because their waters have the property of catching fire. Although these phænomena, like the two preceding, are of a nature different from the subject of this treatise, yet their name and the mention made of one of them by Mr. Valmont de Bomarc, in his excellent Dictionary of Natural History, at the word *Volcano*, authorize us to speak of them.

One of these springs is at Ancliff near Wigan,

in the county of Lancaster. It is mentioned in the part of the Encyclopedia of Perth, that has been published, at the words *Burning Spring*. In that article it is said, that *it has, or had, the property of taking fire and burning like spirits of wine*; which shows the author to be ignorant of the actual state of the spring: nor have I been in a situation to learn any farther particulars concerning it, though I took some pains for that purpose.

I have been more fortunate in my inquiries respecting the other spring. It has not appeared since the falling-in of a coal mine which was near it. This spring had very singular qualities.

It was at Boseley, a place which I find called also Broseley, near Wenlock in Shropshire. It was not known before 1711. After a great hurricane, all the inhabitants of Boseley were suddenly awakened in the middle of the night by violent commotions of the earth, accompanied with a frightful hollow noise. Some had the boldness to go up to a little eminence near

the Severn, whence the noise seemed to come. They perceived that the earth was more agitated there, and that water was oozing with some difficulty through the turf. One of them, to give it a passage, took a spade and opened the ground: on which the water sprang out violently. Some one putting a lighted candle near, brisk flames issued from the water, and were so fierce as to consume large pieces of wood in a very little time. The water itself had no degree of heat, and put upon a common fire, did not begin to boil sooner than any other water.

I am fully sensible how imperfect this account is, but I have not been able to gain any farther information respecting this first eruption.

The spring, after retaining its properties for some years, lost them, but recovered them in the year 1746 in a second eruption, attended with the same circumstances which had appeared with the former. The source was removed a little way, being nearer the Severn by several

yards. In the same year it was found in the following state by one of the Professors of the University of Cambridge :

In a pit, four or five feet deep, and five or six from side to side, there was fixed an earthen jar without a bottom, of the same height as the pit, and four or five inches in diameter. In the jar was a thin blackish mud, which, although cold, was bubbling violently with a hollow deep noise. A light being introduced into the jar, before it was within six inches of the agitated spring, produced instantaneously a brisk flame like that of spirits of wine. It rose half a yard high, and for two days sustained itself without any diminution of strength. It was extinguished by excluding the air, the jar being covered for some moments with a wet cloth.

§ 115. This phenomenon, which disappeared in 1755 after the falling-in of the mine, as we have said, may, and I think must again be generated. The longer the production of it is deferred, the nearer will the properties of the third eruption resemble those of the first, for

they were weakened in the second ; in which it was not, as in the preceding one, a great body of water taking fire in the open air, but to effect the inflammation it was necessary to confine the vapours, and prevent their dispersion. But it is to be presumed, that a new manifestation of this phenomenon would have all the properties of the first after a long lapse of time, as in that case the spirits and oils furnished by an unknown mine of bitumen would be prodigiously accumulated, the aqueous vapours which convey them would be saturated, and the whole soil impregnated with them.

There is no doubt that this mineral, or fossil oil, is petroleum. It takes different names, as naphtha, asphalt, piasphalt, according to the colour of it, or as it happens to be thinner or more viscous. It is found in various places all over the world. When it is produced in any quantity, it is collected with care, as, for instance, at St. Catherine's well near Edinburgh; the produce of which is known under the name of the mineral oil of Scotland. It is more common in the peninsula of Abschiron than in any

other part of the world. Of this we spoke in § 18. All the neighbourhood of Ararat furnishes quantities of it. It is very abundant in Guatemala towards Mexico. It is said that a candle made half of petroleum and half of rosin thrown into water, would every bit of it burn out. It is supposed, that the chief ingredient in the Grecian fire, *feu Gregeois*, that formidable wildfire, the secret of which is lost, was the oil of petroleum, or that of vitriol, for the latter, when put into a vessel with water and some filings of steel, suddenly takes fire, and breaks the vessel to pieces with a frightful noise. In this manner thunder and lightening may be imitated.

There are said to be some other burning springs like those of England, but very few. That of Boseley, however, is the only one, at least to my knowledge, which, in the manner of volcanocs, has denoted its eruptions and action by repeated earthquakes and great subterranean noises. I know not what can be the cause of those prognostications. To account for them, it would be necessary to have

recourse to conjectures respecting the interior of the soil;—this would lead me still farther from the subject of this Treatise, which I therefore hasten to resume.

CHAP. XXXV.

In what cases, and where, is it to be feared that volcanoes may again break out ?

§ 116. **AS** extinguished volcanoes may again break out, may we venture to advance some conjectures on the probability of the rekindling of some of them ; and to point out what circumstances may create apprehensions of the revival of them in countries where they have formerly existed, and in what case there is less foundation for such a fear ?

The revival of a volcano may be suspected in such places as remain subject to frequent earthquakes, because it is very probable that they are occasioned by the continuance of the subterranean fires : in which case there is no difficulty in admitting the possibility of new conflagration.

According to this reflexion, we have reason to believe, that the volcanoes which formerly existed in France will break out no more, that part of Europe being very little subject to earthquakes; a remark made by Pliny, the naturalist, more than seventeen centuries ago. Those of Germany are in the same case. But on the contrary, Calabria has much to fear; for the calamities which befel it in 1783, however frightful they were, did not exceed those which it experienced in 1638, 1659, 1703, and 1744. Asia Minor, especially about Smyrna; and Syria, particularly in the neighbourhood of Antioch, are in the like danger. St. Domingo and several of the Antilles, have cause for apprehension, and also Lima and other parts of Peru, as well as the new kingdom of Grenada, where according to the Abbé Raynal, they have earthquakes almost daily. Canada is also exposed, if we are to believe the *Censeur Universel Anglois* of December 27th 1785, in which it is said that there had been volcanoes there. It is certain that earthquakes are common there in several quarters. In the last century, 1665, there was

one, which, from its effects, was one of the most violent mentioned in history. It suddenly swallowed up a chain of mountains a hundred leagues long. This fact, which is known, is to be found in Valmont de Bomare, under the article *Tremblemens de Terre*. The consequences of these commotions, whatever be their cause, might be very fatal in that extensive region, on account of the immense lakes with which it is covered. We read in the *Bibliothèque Britannique*, vol. ii. that the earthquake which happened in 1796 broke a part of the rock which forms the cataract of Niagara, and that many persons were alarmed at it, knowing that if that rock were in any future commotion to give way fifteen feet lower, Lake Erie would empty itself into Lake Ontario with such rapidity that the inundation would cause infinite havoc.

CHAP. XXXVI.

Of submarine Volcanoes. Their distinguishing character. The number of those known. Volcano of Santorin. Periods of its first eight eruptions in the course of more than two thousand years, and what they produced. Particulars of the ninth eruption in 1767. Production of Black Island.

§ 117. **H**AVING, to the best of my abilities, investigated the nature of volcanoes upon land, it remains for me to treat of those which, being covered by the sea, are known under the name of *submarine volcanoes*.

Their low situation, the reverse of the great elevation natural to those we have been treating of, and the want of a free and constant communication between their fires and the external air, are two circumstances which it should seem might have been the cause of confounding the

submarine fires with those called central, which are not confined to mountains. But it being known that these fires although below the level of the sea occupy in its bosom heights still considerable; that it is from their water-covered summits that these fires escape at intervals; that it is by means of the internal shape of those heights in lengthened tunnels, rising over a vast abyss, that monstrous burning masses are thrown up in whirlwinds of ashes and pumice, and that after these, prodigious torrents of lava are vomited; these considerations, which distinguish them entirely from central fires, and which assimilate them essentially to volcanoes on land, have induced naturalists to class under the generic term of *Volcano* all ignivomous mountains, applying the word absolutely to the mountains on land, and specifying those under water by the addition of the epithet *submarine*.

§ 110. Before we proceed in our inquiry, it will be regular to prove, that there exist fires of this kind; and the more so, because if this phenomenon were not locally ascertained, and were we driven to discuss its possibility, it is in

itself so extraordinary that we should really be tempted to reject the theory of it, and to treat its existence as a chimera. We should in that case resemble the Talapoins of Siam, who, it is known, on being told of ice judged it to be impossible.

Submarine Volcanoes are very few in number. Throughout the seas there are but three points where their situation is ascertained. At Santorin, the Azores, and Iceland. It is said that there are some in the Eastern Ocean, not far from some of the Ladrone Islands: but I have no where read of the spots being fixed. Without disputing the reality of these, I shall for the present pass them over. Nor shall I dwell much on the submarine Volcano of Iceland, although its existence is ascertained. It is opposite Hecla, rather more than two miles from the shore to the South of the island. I shall only mention two of its eruptions. Bleskenius, in his description of Iceland, page 45, gives an account of one of which he was a witness. It began in the night of the 19th of November 1563. At the part of the Ocean

which is in front of Hecla, there issued horrible fires, in such great abundance, says he, that Iceland was entirely lighted by it. The earth shook violently, and raised fears of the island being swallowed up. At the same time subterranean noises, like that of an immense park of artillery, were heard. Such was the thundering of it, adds Blefkenius, that I do not conceive that the crush of the Globe dissolving could exceed it. The sea retired at times from the shore two German miles, about two leagues.

The eruption of 1783 is known to every body. The circumstances with which it was accompanied were similar to those just related. The islands produced by the latter eruption disappeared in the course of a few months.

§ 119. As the volcanoes of Santorin, and of the Azores are more celebrated, the narrative of their motions will probably be thought more interesting.

The island of Thera, afterwards St. Irene, and now Santorin, was surnamed by the Greeks *Καμινος*, that is to say, burnt: and so in

fact the soil is. "There is a tradition," says Pliny, *lib. 2. cap. 87*, "that it rose out of the sea at a very remote but unknown period." This tradition is rendered probable, by the known events which have since taken place near it.

This island with that of Milo, of which we have spoken, and that of Paros, so famous for its marble, forms a triangle, the sides of which are about fifteen leagues each. I suspect that there is a considerable central fire among them, of which the volcano of Milo might have formerly been an exhaling point above water; though it is certainly at present unconnected with it, which appears from the effects of that volcano being in themselves slight, and from the situation of Milo being nowise affected in the great commotions of Santorin. I found my suspicion of this central fire on a vast number of *small burnt islands*, as they are called on the chart of that sea, which are scattered in the midst of the three principal islands, and of which several had not appeared till within the eighteenth century. Almost all of them are

near Milo, where there is less depth of water, I should imagine that these small islands are simply the productions of the central fire. The sea, on the contrary, is very deep towards Santorin, where it covers the mountain, whence proceed incessant eruptions. There is no ground for anchoring near it, as is mentioned by M. de Bomare, *vol. xv. page 120* of his Dictionary already quoted.

Whatever on the surface of this sea-covered mountain be the quantity of matter which has issued from it, when the fires once set in motion in the void at its base within become active, they rise violently, and carry the matter along with them, being always confined in their direction by the internal form of the mountain. Its summit then, and the parts round its summit, are always the points most strongly attacked; there it must and does in fact give way, as is the case with a volcano on land opening for the first time. And when eruptions take place in a submarine volcano, the masses already settled are always affected by them, and partly open, and

their surfaces either gain by the addition and adhesion of new ejections, or lose by some of their parts sinking into the fiery abyss or into the sea. This is confirmed by all the eruptions, and particularly by the circumstances attending the last. They are to be found in all the periodical writings of that time. An account was published by Father Gorée, who was an eye-witness of it, and of his Narrative I will give an abstract, after I have taken notice of the eight known eruptions which were prior to it.

They are all interesting to a laudable curiosity, and proper to throw light on this operation of Nature, but as the circumstances of this grand phenomenon are nearly always alike, I shall do little more than date the former eruptions, reserving for the account of the last the most remarkable particulars which generally attended the eruptions.

§ 129. In the fourth year of the 135th Olympiad, that is to say, in the year 236 before Christ, the island of Therasia rose in the

midst of fire out of the sea: it is separated from Santorin by a strait of a mile and a half in breadth.

A hundred and thirty years after, the island of Automate, which having been consecrated to Vulcan, was afterwards more known by the name of Hieria the Consecrated, rose near it.

After another lapse of a hundred and ten years, in the like manner was formed a third island, called Thia, at two stadia, or two hundred and fifty paces, from Hieria,

These three eruptions are recorded by Pliny, in the place before cited; by Strabo, *lib. 1*; and by Seneca, in his *Naturales Questiones*, *lib. 6, cap. 21*.

In the year 726 the volcano, after violent ejections of ashes and red-hot rocks, disgorged a great quantity of lava, which joined Thia to Hieria.

In 1457 this island was still farther increased, attended by the same circumstances. This event and the date of it, are attested by an inscription on a marble-stone erected near the gate of Fort Scarus, in Santorin.

A sixth eruption in 1570 produced a new island : it is called the Little Kamenoi.

In 1650 the agitations of the volcano lasted almost a twelvemonth. Its greatest convulsions were at the beginning, from its opening on the 24th of September to the 9th of October. The sea rose to the height of forty-five feet, and that to such a distance, that some galleys of the Grand Seignor's were wrecked in the port of Candia, though it is more than eighty miles from Santorin. Smyrna and Constantinople were incommoded with the ashes which rushed out of the sea in whirlwinds of flame. All the particulars of this eruption are to be found in Kircher, a contemporary author, after the account of the preceding.

This inexhaustible volcano again opened in 1707. The Little Kamenoi was increased, and is now more than three leagues in circumference.

Most of these eruptions, and all the circumstances attending the last mentioned, are reported in the 3d volume of the Memoirs of the Academy of Inscriptions, and in those

of the Academy of Sciences, of the year 1708.

§ 121. The eruption of 1767 took place between the Little Kamenoi, and the island of Hiera. It began in the month of June. The earth, after being shaken violently for some days by the action of fire, raised the sea in such a manner as to occasion a dread of its swallowing up all the islands thereabouts. A thick black smoke darkened the air, and infected it with so strong a stench of sulphur, that many persons and animals were suffocated by it. Black ashes, resembling gun-powder, fell all round. Torrents of flame, issuing from the sea, and waving on it to the height of several feet, lighted at intervals this horrible scene. The frightful mixture of different sounds, produced by all the elements in fury, froze every heart with a dread of the horrors which every instant might be the result of their conflict.

At length, after a labour of ten or twelve days, Nature paused, and the effect of her agitation was discovered in a new island, which had risen

near the Little Kamenbi. There was no time lost in going to examine it. Many parts of it were still burning. It was a shapeless mass of baked substances, amalgamated by a lava, which, Father Gorée says, appeared to the eye like the crumb of fine bread. But the very next day the inquirers were compelled to relinquish this hasty curiosity, and betake themselves to flight. They felt the new soil moving: it rose in some parts and sunk in others. The earth, sea, and sky soon resumed their formidable appearance. The symptoms appeared even to spread wider and to threaten worse. The boiling sea several times changed colour: flames, following one another without intermission, issued as from a vast furnace, but accompanied with ashes and pumice. The frightful noise of subterranean thunders was heard. It seemed as if enormous rocks, darting from the bottom of the abyss, beat against the vaults above it, and were alternately repelled and thrown up again: the repetition of their blows, says the author of the narrative, was distinctly heard. Some of them

making or finding a passage, were seen flying up red-hot into the air, and again falling into the sea whence they had just been ejected. Masses were produced, held together for some days, and then disappeared. In this general disorder large portions of the Little Kamenoi were swallowed up. Meanwhile the labour of the volcano took a larger surface; its ejections became prodigiously abundant, and a new island was seen forming. By successive additions, continued for near four months, it made a junction with that produced in June. It was named *the Black Island*, from the colour of its soil. It is nearly twice as large as the Little Kamenoi, and is separated from it by a very narrow strait. The volcano continued creating alarm till the end of May in the following year; frequently shaking the earth and sea, and causing frightful noises. It even opened again, but only for a moment, on the 15th of April, and threw out a multitude of large burning rocks, which fell at the distance of two miles.

It is therefore proved by nine eruptions.

recorded in history, that there exists a maritime volcano at Santorin. These eruptions have happened in the space of twenty-one centuries.

CHAP. XXXVII.

The Maritime Volcanoes of the Azores : 1st.

The eruptions of the volcano of St. Michael :

2d. The eruption of that of St. George.



§ 122. **T**HE state of the soil in several of the Azores, their extinguished volcanoes, their existing ones, the violent commotions to which the islands are subject, the frequent ejection of new islands from the Ocean in certain spots on their coasts, and even the instability of those productions, none of which have hitherto been able to acquire a fixed position on the borders of the crater whence they issued, are all so many circumstances united to leave our curiosity to regret, that we have not more ancient records respecting these islands.

The Azores, or Terceras, as they are some-

times called, from the name of the principal island, were only discovered in the fifteenth century. They occupy a considerable space in the Atlantic Ocean; Fayal, Pico, and St. George's, which lie nearest together, being in the centre of them. Flores and Corvo are to the North-west; Graciosa, Tercera, St. Michael and St. Mary's to the South-east. From Flores to St. Maloes is more than a hundred and eighty leagues.

It is commonly supposed, for the reasons we have just hinted, that these islands rest upon vaults which conceal internal fires, the direction of which, more or less clogged, it is presumed extends to the western coast of Portugal. This presumption arises from the commotions being almost always simultaneous on both sides, notwithstanding the distance is about two hundred and forty leagues.

Three eruptions which took place within a space of ninety-two years in that part of the Ocean, in sight, and very near St. Michael, have proved that a submarine volcano existed there.

In a fourth eruption, a second was shown to be near St. George's, fourscore leagues to the East of the former.

The action and reaction of the same elements among themselves will necessarily produce similar effects. It would therefore be a needless repetition to dwell on the particular circumstances which attended each of those eruptions.

§ 123. In July 1638 near the island of St. Michael, where the sea was known to be a hundred and twenty feet deep, though at a very little distance farther the depth becomes almost suddenly more than nine hundred, there rose, after a labour of several weeks, an island, about six miles round. It was re-absorbed in about the same space of time as it had taken for its formation.

In 1691, from the 6th of July to the 12th of August, this volcano never ceased appearing in agitation, by internal thunders and shocks, that convulsed the island of St. Michael, and occasioned great damage on it, by the heat and violent motions of the sea, and by eruptions of

flames, ashes and pumice: but, in this instance, its ejections did not rise to the level of the Ocean; no new island appeared.

Nine and twenty years after, in 1720, amidst the most frightful complication of horrors, there rose an island, a little smaller than that of 1638, which, however, had sufficient height to be discovered at sea, from a distance of seven or eight leagues. It was observed, to be in the same spot as that which had been occupied by the preceding ephemeral island, but that at the time of this new production, the sea above the summit of the volcanic mountain, was not more than ninety feet. The ruins of the former emissions had probably occasioned this difference: they perhaps also increased the difficulty of the labour of Nature; for so great was the disorder, according to the accounts that were published of this event, that many persons died of fright.

The account of these three eruptions are to be found in Buffon. They are more minutely described in the Memoirs of the Academy of

Sciences, of the year 1721; and they demonstrate the existence of a submarine volcano, near St. Michael's.

§ 124. The eruption of 1757 discovered another of them to us in this cluster. It is, as we have said, eighty leagues distant from the other.

On the 9th of July, a little before midnight, St. George's, Pico, Fayal, three islands forming a closer group among themselves, being scarcely five leagues asunder, and Tercera, though double that distance from St. George's, were suddenly attacked at the same instant, and shaken to their foundations by horrible convulsions of the earth. The first shock lasted two whole minutes. The raised Ocean no longer kept its shores. In this dreadful night many persons lost their lives, and these islands, hitherto fortunate, but at this fatal moment involved in the terrors of desolation, were covered with ruins. I pass over the particulars usual to these sad phænomena, the confused bellowings of land and water, the smoke and ashes which filled the air, and the flames issuing from the Ocean,

to come to the result of this turbulent labour of Nature; which was the production of eighteen little islands, that rose insensibly from beneath the sea, at the distance of about ten yards from the North coast of St. George's. They disappeared in a few months, as those produced by the volcano of St. Michael had done before. The maritime peaks of the Azores have, according to all appearance, less surface than that of Santorin; whence I imagine proceed the instability of the productions of the former volcanoes, and the stability of those of the latter. It was observed that Flores, Corvo, St. Michael and St. Mary's, were not at all affected by the eruption of the volcano of St. George's, and that Graciosa suffered very little.

CHAP. XXXVIII.

Submarine Volcanic Mountains not the productions of central fires. Buffon's opinion respecting their origin. His hypothesis defended. The manner in which the submarine Volcano forms itself. Objection to this opinion: its solution.

§ 125. **T**HE existence of submarine volcanoes being established, the question respecting their origin follows; and it is asked, may not this kind of mountains at least be the productions of subterranean fires? Their mass, it will be said, are small compared to those of volcanoes on land; they may therefore be the effect of an eruption: they may even have been formed by successive eruptions, for contrary to the land volcanoes, to the height of which, the most copious ejections add nothing, these vol-

canoes may acquire elevation, as we have just observed in speaking of the volcano of St. Michael of the Azores, the summit of which in 1720 was not so far by thirty feet below the level of the sea as it was in 1638.

I own I have in vain endeavoured to see a probability in *the formation of a volcanic mountain* by subterranean fires, either on land or under water. I say *the formation of a volcanic mountain*, that being the point in question: for it is agreed, that mountains of the first magnitude may become a volcano. The manner and the causes of it we have endeavoured to illustrate in §§ 24 and 25: but the question here is as to the production of a volcanic mountain throughout its whole substance and form, by a subterraneous fire. This is affirmed, and this seems to me absolutely inconsistent,

Suppose even that the action of that fire should have produced a hill, say as high as that of the sea volcano of St. Michael of the Azores: what have we gained? A shapeless mass, nothing more: for, I presume we shall not be required to admit, that this mass was casually

thrown up from such a chaos, in the form of a volcano, that is to say, exactly perforated in its centre.

I foresee that the answer to this will be, that the hill once produced, afterwards becomes a volcano in the usual way. In *the usual way*? The hypothesis is inadmissible in this case. The laws of Nature, and the state of things, point out to us the powerful and altogether simple mode in which a mountain of a superior order, in consequence of void spaces in its extensive base and perpendicular fissures in its upper part, is compelled to yield to the action of an internal fire, and to be accessory to all its eruptions: but, in the first place, this shapeless hill, produced in the supposed manner, has no fundamental base; it is nothing more than a mass of naked pebbles and burnt rocks, united by the lava, after they had been disgorged on the eminences of the rugged soil covered by the ocean: secondly, it is a mass without any adequate cavern sufficiently extensive to concentrate fires, and to provide it consequently by their efforts with a flue and volcanic mouth;

thirdly, it is an amalgam too unsettled, too irregular, to open of itself into perpendicular fissures : and, from this close state of it, could the internal fire again make a passage at the same point, which I think it cannot, the action of it would throw down this little mount, but would never transform it into a volcano. I say, *I think it cannot*, for a reason I have already assigned. A volcanic mountain is, as justly expressed by M. de Buffon, a cannon of an immense body. The discharge will always be repeated by the mouth, because the direction forces it that way : thence proceed the eruptions constantly reiterated even of submarine volcanoes as we have seen, in, or towards the same point. The subterranean fire, on the contrary, when its action is not in a similar manner constrained and directed, must, after one emission, seek another passage, and attack a different point than that which it has strengthened by its preceding discharge.

We have, it is true, in § 34, spoken of some elevations which are formed on the side of a great volcano during its commotion. These are

but slight eminences, rarely, though sometimes, open in their centre, and able to disgorge: and the phenomenon is the result of certain pre-dispositions, without which it would not have taken place. The fermenting matter in a vast cavernous base rises and makes its way into the upper region of the mountain. Violently concentrated and compressed in the narrower parts of the volcano, should the lava push against a point that had been much weakened, yet too strong to give way till forced by a great over-charge, it makes a shoot, the height of which is the same as that to which the great mass of lava is risen in the inside of the volcano. The exterior sides of this shoot consolidate at the very time that the lava and flames are escaping through its centre. When at length the matter settles in the abyss, this little shoot may sometimes remain slightly open, and there is nothing to prevent the issue of some matter by this orifice, at the time of a new eruption. Here it is evident, we have only the effects of known causes; whereas in the hypothesis we oppose,

effects are taken for granted without any causes for them.

§ 126. On the origin of submarine volcanoes, I prefer following the opinion which seems to me to be that of M. de Buffon.

It has been observed, says he, in his Theory of the Earth, article 17, that there is no instance of islands being *produced* far at sea unconnected with other shores. It is always near some old islands that new ones appear. The latter therefore rise from the continuation of the mountain, by which the neighbouring island is formed.

Let us first defend the observation alledged by Buffon; we will afterwards show the consequences which result from it. I anticipate my readers, in regretting that that learned historian of Nature, justly called the Pliny of our age, did not himself perform this task.

§ 127. The part of the globe covered by the sea is divided, like the dry land, into hills, valleys, and plains. Among the maritime mountains there are some that rise above the waves,

and they are called islands, shoals, and rocks. These we pass over, being at present only concerned with those whose tops remain under water, which contain fires, and from which new islands are formed. These are the heights which M. de Buffon says, are only the appendages, the continuation under water of the more elevated mountains above it, which constitute the adjacent islands.

This is evidently the state of the two submarine volcanoes of the Azores, and that of Iceland. They are very near those islands in which there have been, and in some of which there still are high burning mountains.

The submarine volcano of Santorin is, perhaps, too far distant from Milo for us to suppose it a continuation of that island. But it is a fact, demonstrated by the present state of things, that there was a time when most of the islands of the Archipelago were burning. Is there any absurdity in supposing, that in those remote times a volcano above water should have sunk in the neighbourhood of Santorin, and its continuation preserved?

I shall adduce a known situation in the West-Indies to justify this opinion. We read in Father Labat, that about five and twenty or thirty yards from the shore, on the West-side of Guadaloupe, the water of the sea is always boiling. The cause is easily ascertained. By digging the ground on shore in different places, says that historian, from sixteen to eighteen inches deep, in a direct line from the boiling point of the ocean to the volcano of La Souffriere, the earth is found to be burning. It is, therefore, manifest, that there is here a continuation carried off from La Souffriere, which though sunk below the level of the water is still raised in the bed of the ocean, and that in the continuation there exist powerful fires.

Now, let us suppose for a moment, that by some accident this communication were cut off; the volcano might become a double one, the original one remaining on the island, and the secondary one becoming a submarine volcano. La Souffriere might in time be extinguished, or the top sink in altogether, while the submarine volcano continued to exist.—To a similar

casualty might we ascribe the origin of the volcano of Santorin.

As to those which from many testimonies I am induced to admit in the Eastern Ocean, but of which the exact positions are not pointed out, or are at least unknown to me; if they are situated near islands, I should class them with the submarine volcanoes of the Azores, or that of Iceland; and if at too great a distance, I should consider them according to the hypothesis we have been supporting relative to the volcano of Santorin, as the whole state of that part of the globe in which the Eastern Ocean lies, justifies us in thinking that it has suffered most dreadfully. The islands in this sea, both clustered and scattered, are without number: near twelve hundred are reckoned in the Philippines alone: those of the Moluccas, Carolinas, Pelew, Mariannas, and Lekeyos, present an immense multitude. In several islands of these clusters there are volcanoes found burning, whose numbers exceed those extinguished there. This sea in general is of all others the least deep; and it is believed, that navigation is

carried on over a great continent, which has been swallowed up. In several of the shallows the water is hot, and at times smoke and flames have been seen rising from them. When there is a concurrence of so many circumstances indicating some the marks, and others the causes of great revolutions of Nature, there is nothing strange in supposing that here the fire may have supported itself in the appendage of some volcanic island which had been swallowed up.

I allow, however, that this is simply an inference; but it would be unjust to consider it as entirely arbitrary, for it is drawn from local circumstances, and, what is much in favour of M. de Buffon's opinion is, that it at once removes an exception to the general order of things, an exception which was a stumbling-block in this part of the natural history of the earth. We see how a mountain may become volcanic even below the level of the sea; the low position of such a volcano is no longer an enigma, we have the solution of it: the mountain seems to belong to the lowest order, but

the base and the abyss of it are those of a grand order.

§ 128. Should there be any difficulty in conceiving, that the fires can be separated and concentrated in the submarine continuation of a volcano on the shore, the latter still existing as in Iceland, or extinguished as in the Azores, or sunk as at Santorin; among other hypotheses that might be supported, we shall find the circumstance and its effects possible, by admitting, First, that under the mouth of the original volcano, but at a great depth, there were two separate abysses. I say at a great depth, that being of importance, as all obstruction in the upper part, towards the mouth of the volcano, must necessarily be removed: for the matter that it would form, being in this case placed in a line nearly perpendicular, would be forced to yield to the violence of the fires, which it must have concentrated for some moments: Secondly, that some great disorder in the inside of the mountain may have entirely cut off one of these abysses from its connexion with the upper part of the mountain: Thirdly, that the fires re-

maining in the abyss corresponding with the continuation of the mountain under the sea, may have opened a new mouth. Let us briefly examine these three positions.

The first:—There is nothing extraordinary in the state of a very lofty mountain rising over a double abyss: it is probably even the most usual one of volcanic mountains. When speaking of the astonishing quantity of the ejections of Vesuvius and Etna, we observed, that an immense void must be the consequence of them, we did not assert that it was the same cavity that furnished them all; but we expressed an opinion, that there were separate ramifications, lower than the visible base, by which a communication was kept open between the mouth and various fiery reservoirs. Solid masses dividing these gulfs from one another, serve to support the summit above them. Farther, it is remarked, that in some volcanic agitations the rolling of the subterranean thunders proceeds alternately from different regions of the mountain: and this proves that these are distinct cavities, which, though at a distance from one

another, have a correspondence with the same mouth.

The second :—That after a violent commotion within a volcano, one of the abysses should be cut off from the other, is a circumstance, the possibility of which will not be disputed by any who are at all acquainted with the prodigious effects of those phænomena. To go no farther, among a thousand instances, than to the late commotions which took place in Peru in 1797 ; have we not seen, on the same day, Cuero fall and crush a town situated at its foot ; a part of the mountain Biabamba sink into the abyss, carrying with it the city of the same name and all its inhabitants ; and Mount Yaragni disappear altogether, leaving a frightful gulf in its place ? Surely then the obstruction we have stated is much less extraordinary.

The third :—To complete the formation of this secondary volcano, all we want is a new mouth ; for that of the original volcano either no longer exists, or is nothing to the fires now cut off from it. Those fires still occupy an

immense reservoir, whether they were from the first concentrated in the original volcano, finding in that sufficient aliment ; or whether they had been other subterranean fires which had flowed into the cavities of its base. Is it to be doubted, that in such a state, at the time of a great effervescence, the top of the continuation may, nay, must open, and give a vent to eruptions ?

§ 129. A specious objection may here be made. If objections arise against the clearest and simplest positions, we ought to expect them in the unfolding of a secret of Nature. It may be said :

“ If such be the origin of submarine volcanoes, if the separation of a part of the fires of an original volcano is able to give birth to a secondary one below the level of the sea, a similar accident must surely have taken place on some part of the dry land, and we should also see volcanoes even with the ground. That not being the case, it should seem that Buffon’s hypothesis must be given up.”

In respect to this separation of the fires resulting solely from internal circumstances, ab-

solutely peculiar to the original volcano; as M. de Buffon supposed, that it had taken place in some quarters of the sea, he certainly would not have denied the possibility of a similar separation in a continental volcano in similar internal circumstances.

But he might very justly have denied the inference, that we should also see volcanoes even with the ground. The difference in the external circumstances of the two continuations, and a contrary position, prevent such an accident from having a similar effect.

In Buffon's hypothesis, the continuation, although sunk below the level of the sea, is still elevated over its depths, and disgorges freely: a mountain of this kind then may well remain volcanic.

On the contrary, in the hypothesis we combat the continuation being above water, and the mouth even with the ground, the lava could not run off. In vain would it rise, it would be impossible for it to discharge itself in sufficient quantity to empty the basin it fills, and it would therefore necessarily clog it. Lava does not

spout out ; it is the boiling that raises it : the matter which is very thick is disgorged with difficulty and slowly, even from a very elevated mouth : in the instance put, it is forced to accumulate on the spot, and it is only by flowing mass over mass that it can spread upon the plain. When the external air has acted upon it, and the whole mass become stiff and solid by degrees, from the extremities to the part which covers the opening, no new emission can be expected in that place. A continental continuation then will never become volcanic even with the ground, because from its position it wants a requisite essential to every volcano ; that of a raised chimney for the dispersion of its lava. Suppose that the summit of Etna, so famous for the abundance of its emissions, were reduced to a level with the country, lava might perhaps again rise and flow over its vast mouth, but it would certainly be the last time, at least by that passage, which would ever after remain sealed up. Farther, should the fires of this volcano, thus concentrated, open a secondary mouth in one of the flanks of the

mountain under the level of the sea; as this mouth, which, though sunk, would still be an elevation in the depths of the sea, would have the requisite height to facilitate eruptions, it would produce a submarine volcano.

To prevent every objection which may arise, though collaterally, on this subject, let me add that there is a case, in which a choked volcano on land may, in my opinion, give birth to a secondary one also on land. It is on the supposition that the distant cavity in which are centred fires, whose communication is cut off, instead of being beneath a plain is beneath another peak, the side of which rests, at a greater or less depth, on the base of the original volcano, and which, by the extensive continuation of all its other parts, includes the fiery abyss. It must also be supposed, that this peak is opened within by one or more perpendicular fissures, which might have been occasioned either by some former accident, or by the shocks of the original volcano. In this case, but in this alone, we may conceive it possible for a secondary volcano on land to be formed: but here too we

should have, conformably to what we have said before, particularly in chapter viii. § 35, a massy and lofty mountain.

We may in this manner be able to account for the proximity to one another of a number of volcanoes which were formerly burning in Velay, Vivarais, Auvergne, and some other parts of the world. It is very possible that several may have been but secondary formations, and perhaps even without the necessity of the original volcano being entirely choked up.

CHAP. XXXIX.

Why does not the sea inundate a submarine Volcano when it opens? How does the crater of a submarine Volcano close itself under water?

§ 130. **THAT** a submarine volcano once opened should remain unextinguished, is a fact which, though certain, astonishes and almost appears an absurdity to the imagination. It is a part of our task to investigate the manner in which it supports itself; and the following questions of course immediately suggest themselves: 1st. Why is it not overwhelmed by a deluge from the sea? 2dly, How does its crater close?

Let us descend into the depths of the ocean where it is rendered hot by being in contact with a mountain it covers, which is consumed

within by intense fires. Bolder still, let us introduce ourselves into this immense fiery gulph, where all the elements are at war, and let us place ourselves near the part of the summit which is about to give way, and open a passage between the abyss and the sea above it. What a scene presents itself ! It requires the pen of a Milton.

A great body of inflamed air, by the excess of its dilatation, after many repeated claps of thunder, and efforts that have several times shaken the earth and raised the sea, at length forces the barrier which confined it. Accumulated columns rush through the breach with irresistible violence, and carrying along with them a part of the roof of their prison, leave the fiery abyss accessible to the ocean. In this first paroxysm of frantic liberty, the air will doubtless prevail against the water, will repel it, and prevent it from falling in. But will the sea remain suspended over an open gulf without pouring into it ? Assuredly not ; I have no such idea ; particularly as we know that this state of the volcano is very far from being momentary, but

lasts, as we have seen, whole months, during which the water may pour into it, either by the principal mouth, or by a multitude of passages, till all the apertures are completely closed. Besides, it cannot be denied, that after the eruption of a certain quantity of air, the force of resistance being less at the mouth of the volcano, a stream of water must begin to run in. How does it happen then, that the sea pours into this gulf without entirely inundating, and consequently extinguishing its fires for ever ?

This effect is prevented by the inconceivable rarefaction, which suddenly takes place in this torrent of water, previously boiling, and of course less in its mass, as it enters this immense furnace turning into steam. What a degree of fresh strength does the internal air acquire even by this ! As it has no passage but by the crater just opened, where of course it will centre all its efforts to resist, and to disengage itself, there will the fire once more oppose and repel the water ; there will take place frequent alternate successes and defeats

between the hostile elements, and were the abyss of the volcano of inferior magnitude, I should readily believe, that the strife would soon terminate to the disadvantage of the fire, that the water would fill the void, and for ever after occupy it. This has probably happened in several parts of the Ocean; but at present we are speaking of those submarine volcanoes which for ages have opened and closed. We must, therefore, suppose, that they have reservoirs immensely capacious in breadth and in depth: in which case, the inexhaustible body of air which they contain, will continue the struggle until this astonishing breach shall be at length repaired.

§ 131. Where is the potent arm that shall execute this idea? Whence is to proceed the great and chief materials necessary for the purpose? What force is to direct and keep them together? Where is the solder to be got which is to complete this work, and cement all the pieces of it?

Let us have recourse to the knowledge we

have already gained of the process of Nature in volcanoes on land : it must be the same here with some modification of circumstances. Prodigious masses, accompanied with heaps of calcined pebbles and ashes, are ejected from the bottom of the volcano, or from the sides within. Let us observe, that the resistance of the water prevents these bodies from rising out of the submarine crater as high as they would from a crater in open air : whence it follows, that, if we except the lighter ones, which the agitation and fluctuation of the sea may carry off, almost all these bodies, particularly the more massy ones, will fall either perpendicularly into the mouth of the volcano to be again ejected, or, by the confusion of the shocks, inclining from the perpendicular, drop upon the borders of the crater, which they will contract by degrees, and continue contracting till they quite shut it up. That this blind, undirected, operation will not be the work of a day will be easily imagined : it will require weeks and months to complete it, but it will at length be

completed with the very materials produced by a continuance of the eruption. The pumice, ashes, and remainder of the lava will form the cement, that will finally seal up the crater.

CHAP. XL.

*Where was the ancient Atlantic territory situated?
Of what extent was it? Its destruction, and
the consequences that must have followed. The
reasons for which it has been presumed that
its ruin was caused by its volcanic fires.*

§ 132. **T**HIS Treatise is now concluded: and perhaps it will be thought too long. Notwithstanding what I have suppressed, it is certainly longer than I intended it to be. What follows I should also have omitted, even rather than what I have thrown out, because, in fact, it treats only of a mere conjecture, if, to the inducement arising from volcanoes being the object of it, that conjecture did not add the interest naturally excited by an inquiry into the causes of the greatest and most calamitous re-

volution of Nature, of which the memory has been preserved on our globe.

We hear from antiquity of an island so large that it was considered as a continent: it was called *the Atlantic Territory*. It was situated to the West of Europe and Africa, and not very distant from those quarters of the world, to which it was equal in extent. But let us remember that the geographical knowledge of the ancients was, in those remote ages, very imperfect. They were acquainted only with the southern parts of Europe, and the North coasts of Africa, as far as Mount Atlas. West of the Atlantic territory, there was a very extensive country watered by large rivers. That country is evidently America. From these *data* then we may suppose, that the Atlantic Territory extended from the Azores, by Madeira and the Canaries, perhaps as far as the Cape de Vend islands, forming its eastern extent; and that from that line it stretched off to the westward twice as far in longitude, approaching more or less the islands in the Gulf of Mexico. Kircher, in the map he has given of the Atlantic Terri-

tory, which accompanies his work, *Mundus Subterraneus*, lays down the boundaries of that island much less to the westward than has since been done by the celebrated Tournesfort, who is of opinion, that even the islands in the Gulf of Mexico made a part of it.

§ 133. This prodigious island fell to pieces and was swallowed up in the abysses of the earth in consequence of tremendous earthquakes, which continued incessantly for three days and three nights. This event took place before the art of writing was known in the West, and probably very long before: therefore time has nearly effaced the very remembrance of the existence of the Atlantic territory, and its dreadful dissolution. Antiquity furnishes us with only one authority for them, but that authority is Plato's, derived from the Egyptian Annals, which are lost.

The learned, says Kircher, who was himself a very distinguished writer of that select class, have deviated from the account of that great philosopher, respecting the period of this fatal

subversion, placed by him nine thousand years back, which would make it at present eleven thousand two hundred years: and also respecting the history of the war of the Atlantic nations against the Egyptians and Grecians: but the learned all agree, adds Kircher, in allowing the existence and destruction of that unfortunate island.

It was at that era, according to many naturalists, that in consequence of the absorption of so immense a portion of the earth, the agitated ocean opened a passage for itself, between Europe and Africa, by Gibraltar, and formed the Mediterranean, at the same time separating Ireland from Great Britain, and the latter from the Continent.

I readily believe, that many revolutions of Nature have happened to the globe since it issued from the hands of its Creator, and that even those which we have just mentioned are in the number. I should not, however, so readily ascribe them to that extraordinary event; especially as in the natural course of things,

there are other causes that present themselves. A discussion of these would lead me too far, and is foreign to the subject of volcanoes.

The fate of the Atlantic Territory must certainly have occasioned much havoc on the surrounding coasts; and such violent commotions of the land must necessarily have been attended with dangerous fluctuations of the sea. But if we do not abandon ourselves too much to our imagination; if we reflect that the absorption of this continent was owing solely to its situation over vaults which fell in; we shall immediately conclude, that the result of this sudden fall was; that the precipitated mass either filled the void which existed under those immense vaults, in which case the Ocean would keep its original level, or, that it took the place occupied by the water, and then the Ocean indeed must have risen in a degree proportionate to the mass of the Atlantic continent above it before it sunk: but this elevation once spread, could be but very little when shared by the whole ocean; so that on a calm being restored, and the gene-

ral equilibrium re-established, the Ocean must have retained, within a very little, its former bounds.

§ 134. It is generally thought that it was the multitude of volcanoes, and the internal fires of the Atlantic island that destroyed it. The following are the reasons on which this conjecture is founded.

First, the lofty mountains to the East of the situation of the Atlantic Territory have almost all been burning, or are still burning. The Azores are noted for their fires, both above and below the sea. Doctor Williams, who was in the suite of Lord Macartney's Embassy to China, observed an extinguished volcano on the East-side of Madeira. There are both extinguished and burning volcanoes in the Canaries, and also in the Cape de Verd Islands.

Secondly, the corresponding extremities of that situation to the West are in the same state as those to the East. Almost all the Leeward Islands have had volcanoes, and there are

several heights among them that still constantly emit smoke.

Whether the spots mentioned belonged to the Atlantic Territory or not, it remains certain that on both sides of the space occupied by that immense island, the earth undermined by Nature contains vast caverns, which are full of inflammable matter, and in several of which the fire is still alive.

Thirdly, if we proceed to the East over a part of the latitudes immediately corresponding to the situation of the Atlantic Territory, from Portugal to Asia Minor and Syria, we shall find those regions of the earth in a state very analogous to that of the two extremities we have just mentioned : that is to say, that it contains, at intervals, immense caverns, several of which communicate with one another, where sulphur and all phlogistic substances abound, and that a number of those abysses are on fire. This state is unfortunately but too well demonstrated by the frequency and extent of the earthquakes to which the whole of those latitudes is subject,

by the number of volcanoes with which it has been covered, and by those which still exist there in great force, besides several vents which are incessantly exhaling sulphureous smoke.

These first three considerations have given grounds for conjecturing that the Atlantic island was supported on a soil undermined in like manner, but more dangerously still than the regions we have just mentioned, and was swallowed up from the rapid communication of the fires in every part of its interior, and the general explosion that followed of the vaults on which it rested. The following observation confirms this opinion.

Fourthly, It is a known fact, though it always surprises, that after storms, or even rough weather, the sea near the Antilles is constantly seen covered with an immense quantity of white, brown, and blackish pumice stones, and the shores are loaded with it. It is true, that pumice of the same quality is also seen in the seas near Sicily and Naples, but it is not found in such quantity, although it should, in fact, be

in greater ; for there, as in the Grecian archipelago, where the same phenomenon is observed, the pumice is shut up in narrow seas, where the waves can only run from one side to another, and therefore their original quantity, which is always kept up by a greater number of fires that are still existing there, should remain, as it suffers no loss but of a small portion taken for trade, of which the choice of the pumice is an object : whereas the Ocean, which never ceases rolling in a body from East to West, and which is known to pass violently through all the Antilles, towards the great continent of America, should necessarily clear the seas about those islands, of the pumice produced by their own volcanoes. As these substances nevertheless abound there, the Ocean must carry them thither from some other place : whence it may be inferred with great probability, that the ground of the sea to the East of the Antilles, that is to say, the ancient Atlantic Territory, is covered with volcanic ruins. The waves which are incessantly washing it

in every part, raise the lighter substances of it, such as the pumice, and drive them progressively, in consequence of the general undulation of the sea, in the direction above-mentioned, towards the shores of the Antilles.

THE END.